METHYL BROMIDE CRITICAL USE NOMINATION FOR PREPLANT SOIL USE FOR CUCURBITS GROWN IN OPEN FIELDS

FOR ADMINISTRATIVE PURPOSES ONLY:
DATE RECEIVED BY OZONE SECRETARIAT:

YEAR: ***CUN:***

NOMINATING PARTY:	The United States of America
BRIEF DESCRIPTIVE TITLE OF NOMINATION:	Methyl Bromide Critical Use Nomination for Preplant Soil Use for Cucurbits Grown in Open Fields (Prepared in 2005)

NOMINATING PARTY CONTACT DETAILS

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Following the requirements of Decision IX/6 paragraph (a)(1), the United States of America has determined that the specific use detailed in this Critical Use Nomination is critical because the lack of availability of methyl bromide for this use would result in a significant market disruption.

☐ Yes ☐ No

Signature Name Date

Title: ______________________________

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LIST OF DOCUMENTS SENT TO THE OZONE SECRETARIAT IN OFFICIAL NOMINATION PACKAGE

List all paper and electronic documents submitted by the Nominating Party to the Ozone Secretariat

1. PAPER DOCUMENTS: **Title of Paper Documents and Appendices**	**Number of Pages**	**Date Sent to Ozone Secretariat**

2. ELECTRONIC COPIES OF ALL PAPER DOCUMENTS: **Title of Electronic Files**	**Size of File (kb)**	**Date Sent to Ozone Secretariat**

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PART A: SUMMARY

1. NOMINATING PARTY:

The United States of America

2. DESCRIPTIVE TITLE OF NOMINATION:

Methyl Bromide (MB) Critical Use Nomination for Preplant Soil Use for Cucurbits Grown in Open Fields (Prepared in 2005)

3. CROP AND SUMMARY OF CROP SYSTEM

Cucurbits (squash, melons, and cucumber) grown in Alabama, Arkansas, Georgia, Kentucky, Louisiana, Michigan, North Carolina, South Carolina, Tennessee, and Virginia. These crops generally are grown in open fields on plastic tarps, often followed by various other crops. Harvest is destined for the fresh market.

4. METHYL BROMIDE NOMINATED

TABLE 4.1: METHYL BROMIDE NOMINATED

YEAR	NOMINATION AMOUNT (KG)*	NOMINATION AREA (HA)
2007	**598,927**	**4,026**

* Includes research amount of 941 kgs.

5. BRIEF SUMMARY OF THE NEED FOR METHYL BROMIDE AS A CRITICAL USE

The U.S. nomination is only for those areas where the alternatives are not suitable. In U.S. cucurbit production there are several factors that make the potential alternatives to MB unsuitable. These include:

- The efficacy of alternatives may be significantly less effective than MB in some areas, making these alternatives technically and/or economically infeasible for use in cucurbit production.
- Some alternatives may be comparable to MB as long as key pests occur at low pressure, and in such cases the U.S. is only nominating a critical use exemption (CUE) for cucurbits where the key pest pressure is moderate to high such as nutsedge in the Southeastern U.S.
- Regulatory constraints prevent use of some chemicals, e.g., 1,3-dichloropropene (1,3-D) use is limited in Georgia due to the presence of karst geology.
- Delays in planting and harvesting result in users missing key market windows, and adversely affect revenues through lower prices. Delays in planting and harvesting: e.g., the plant-back interval for 1,3-D+chloropicrin is two weeks longer than MB +chloropicrin, and in Michigan an additional delay would occur because soil temperature must be higher to fumigate with alternatives.

In Michigan cucurbits, 1,3-D + chloropicrin is the best registered alternative for the control of the key target pests. These pests are the soil borne fungi *Phytophthora capsici* and *Fusarium oxysporum*, both of which can easily destroy the entire harvest from affected areas if left uncontrolled. At least one of these pests, *P. capsici*, has recently been shown to occur in irrigation water in Michigan (Gevens and Hausbeck, 2003) and has probably contributed to the spread of this pathogen. Due to widespread pest distribution, virtually all of the cucurbit hectares in Michigan currently use MB (plus chloropicrin) as a prophylactic control. While 1,3-D + chloropicrin provided some control of fungi in recent small-plot trials with cucurbits in Michigan (Hausbeck and Cortwright, 2003), there were yield losses (approximately 6%) relative to the MB + chloropicrin standard.

It is also not yet clear whether these small-scale results accurately reflect efficacy of MB alternatives in commercial cucurbit production. Furthermore, regulatory restrictions due to concerns over human exposure and ground water contamination, along with the lower yields, result in potential economic infeasibility of this formulation as a practical MB alternative. Key among these factors are a delay in planting up to 14 days relative to MB, due to a combination label restrictions and the low soil temperatures typical of Michigan**,** as well as a mandatory 30 m buffer for treated fields with 1,3-D + chloropicrin near inhabited structures. Delays in planting may result in growers missing key market windows and premium harvest prices, and buffer zones will result in some areas remaining vulnerable to pests in the absence of MB.

In the Southeastern U.S. (including Georgia), nutsedges are the primary target pest of concern. Some growers in this region also face root-knot nematodes and the soil-borne fungal pathogens (described above) as key pests. Left uncontrolled, any of these pests could completely destroy the harvests from affected areas. Metam-sodium offers some control of nutsedges and nematodes, while 1,3-D + chloropicrin provides good control of nematodes (e.g., Eger, 2000; Noling et al., 2000). However, in areas where nutsedge infestations are moderate to severe and fungal pathogens are present, metam-sodium results in an estimated 44 % yield loss relative to MB (Locascio, et al., 1997). In such areas, use of 1, 3-D + chloropicrin is likely to lead to an estimated 29 % yield loss relative to MB (Locascio, et al., 1997). In addition to these estimated losses, it must be noted that 1,3-D + chloropicrin cannot be used in large portions of the southeastern U.S. (primarily Kentucky and Georgia as regards this nomination) due to the presence of karst geology. 1,3-D cannot be used on such soil due to label restrictions created in response to concerns over groundwater contamination. Together, these yield losses and regulatory restrictions render these promising MB alternatives technologically and economically infeasible.

It should be noted also that all studies of yield losses for metam-sodium and 1,3-D + chloropicrin relative to MB are based on small plot research trials done on non-cucurbit crops. Large-scale on-farm trials will need to be conducted in cucurbits with high fungal and nutsedge pest pressure to determine the long term potential for these alternatives.

Some researchers have also reported that these MB alternatives are degraded more rapidly in areas where they are applied repeatedly, due to enhanced metabolism by soil microbes. This phenomenon may compromise long-term efficacy of these compounds and appears to need further scientific scrutiny. Neither of these promising MB alternatives is presently adequate for control of key pests, and MB remains a critical use for cucurbits in Michigan and in the southern states.

Michigan, Southeastern U.S. (except Georgia), and Georgia are presented as separate regions in this nomination to reflect the separate applications from growers in these areas.

TABLE A.1: EXECUTIVE SUMMARY

Region	***Michigan***	***Southeastern U.S. (except Georgia)***	***Georgia***
AMOUNT OF NOMINATION			
2007 Kilograms	**26,592**	**368,034**	**203,361**
AMOUNT OF APPLICANT REQUEST			
2007 Kilograms	26,592	959,129	405,837

6. SUMMARIZE WHY KEY ALTERNATIVES ARE NOT FEASIBLE:

Our review of available research on all other MB alternatives discussed by MBTOC for cucurbits suggests that, of registered (i.e., legally available) chemistries only metam sodium and 1,3 D + chloropicrin have shown potential as commercially viable replacement to MB. Non-chemical alternatives are either unviable for US cucurbits or require more research and commercial development before they can be technically and economically feasible.

For Michigan pests 1,3 D + chloropicrin is the only key alternative with efficacy comparable to MB. However, it has regulatory restrictions due to human exposure concerns, along with technical limitations, that result in economic infeasibility of this formulation as a practical MB alternative. Key among these factors are a delay in planting as long as 30 days, due both to label restrictions and low soil temperatures, and a mandatory 30 m buffer for treated fields near inhabited structures.

For Southeastern U.S. and Georgia, metam-sodium and 1,3 D + chloropicrin are the most promising alternatives for nutsedges and nematodes, respectively, which are the key target pests in these regions. However, where nutsedges are severe, metam-sodium is technically and economically infeasible due to planting delays and yield losses, while 1,3 D + chloropicrin is infeasible due to (1) its use being prohibited on Karst geology, which are widespread in these regions, (2) a 21 day planting delay, and (3) yield losses. These effects have been discussed in Section 5 (above).

There is also evidence that the pesticidal efficacy of both 1,3 D and metam-sodium declines in areas where it is repeatedly applied, due to enhanced degradation of methyl isothiocyanate by soil microbes (Ou et al., 1995; Verhagen et al., 1996; Dungan and Yates, 2003; Gamliel et al., 2003).

All other potential or available MB alternatives are also technically infeasible for U.S. cucurbits (see Section 13 of each region for further details).

7. (*i*) PROPORTION OF CROPS GROWN USING METHYL BROMIDE

TABLE 7.1: PROPORTION OF CROPS GROWN USING METHYL BROMIDE

REGION WHERE METHYL BROMIDE USE IS REQUESTED	TOTAL CROP AREA IN 2003 (HA)	PROPORTION OF REQUEST FOR METHYL BROMIDE IN 2007 (%)
Michigan	8,620	3%
Southeastern U.S (except Georgia)	18,858	34%
Georgia	25,204	11%
NATIONAL TOTAL:	52,682	18%

7. (*ii*) IF ONLY PART OF THE CROP AREA IS TREATED WITH METHYL BROMIDE, INDICATE THE REASON WHY METHYL BROMIDE IS NOT USED IN THE OTHER AREA, AND IDENTIFY WHAT ALTERNATIVE STRATEGIES ARE USED TO CONTROL THE TARGET PATHOGENS AND WEEDS WITHOUT METHYL BROMIDE THERE.

In Michigan, all acreage is treated with MB due to cool weather conditions and high pest pressure from diseases and weeds.

In Southeastern U.S. and Georgia, areas not treated do not have nutsedges, or nematodes naturally present in cucurbit fields. Simple absence of all pests is the only reason these areas are not presently treated with MB.

7. (*iii*) WOULD IT BE FEASIBLE TO EXPAND THE USE OF THESE METHODS TO COVER AT LEAST PART OF THE CROP THAT HAS REQUESTED USE OF METHYL BROMIDE? WHAT CHANGES WOULD BE NECESSARY TO ENABLE THIS?

The primary reason that some cucurbits may be grown without methyl bromide in all three regions is the absence of key target pests (i.e., nutsedge in the Southeast, and Georgia, soil pathogens and cold soil temperatures in Michigan, and karst geology in Georgia.

8. AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

MICHIGAN - TABLE 8.1: AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

REGION:	
YEAR OF EXEMPTION REQUEST	**2007**
KILOGRAMS OF METHYL BROMIDE	26,592
USE: FLAT FUMIGATION OR STRIP/BED TREATMENT	Strip/Bed
FORMULATION *(ratio of methyl bromide/chloropicrin mixture)* TO BE USED FOR THE CUE	67:33
TOTAL AREA TO BE TREATED WITH THE METHYL BROMIDE OR METHYL BROMIDE/CHLOROPICRIN FORMULATION *(ha)*	221
DOSAGE RATE* (g/m^2) OF **ACTIVE INGREDIENT** USED TO CALCULATE REQUESTED KILOGRAMS OF METHYL BROMIDE	12.0

** Only strip treatments are made.*

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - TABLE 8.2: AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

REGION:	
YEAR OF EXEMPTION REQUEST	**2007**
KILOGRAMS OF METHYL BROMIDE	959,129
USE: FLAT FUMIGATION OR STRIP/BED TREATMENT	Strip/Bed
FORMULATION *(ratio of methyl bromide/Chloropicrin mixture)* TO BE USED FOR THE CUE	67:33
TOTAL AREA TO BE TREATED WITH THE METHYL BROMIDE OR METHYL BROMIDE/CHLOROPICRIN FORMULATION *(ha)*	6,386
DOSAGE RATE* (g/m^2) OF **ACTIVE INGREDIENT** USED TO CALCULATE REQUESTED KG OF METHYL BROMIDE	15.0

** * Only strip treatments are made.*

GEORGIA - TABLE 8.3: AMOUNT OF METHYL BROMIDE REQUESTED FOR CRITICAL USE

REGION:	
YEAR OF EXEMPTION REQUEST	**2007**
KILOGRAMS OF METHYL BROMIDE	405,837
USE: FLAT FUMIGATION OR STRIP/BED TREATMENT	Strip/Bed
FORMULATION *(ratio of methyl bromide/Chloropicrin mixture)* TO BE USED FOR THE CUE	67:33
TOTAL AREA TO BE TREATED WITH THE METHYL BROMIDE OR METHYL BROMIDE/CHLOROPICRIN FORMULATION *(ha)*	2,703
DOSAGE RATE* (g/m^2) OF **ACTIVE INGREDIENT** USED TO CALCULATE REQUESTED KG OF METHYL BROMIDE	15.0

** * Only strip treatments are made.*

9. SUMMARIZE ASSUMPTIONS USED TO CALCULATE METHYL BROMIDE QUANTITY NOMINATED FOR EACH REGION:

The amount of methyl bromide nominated by the U.S. was calculated as follows:

- The percent of regional hectares in the applicant’s request was divided by the total area planted in that crop in the region covered by the request. Values greater than 100 percent are due to the inclusion of additional varieties in the applicant’s request that were not included in the USDA National Agricultural Statistics Service surveys of the crop.
- Hectares counted in more than one application or rotated within one year of an application to a crop that also uses methyl bromide were subtracted. There was no double counting in this sector.
- Growth or increasing production (the amount of area requested by the applicant that is greater than that historically treated) was subtracted. The applicants that included growth in their request had the growth amount removed.
- Only the hectares with one or more of the following impacts were included in the nominated amount: moderate to heavy key pest pressure, karst geology, unsuitable terrain, and cold soil temperatures.

MICHIGAN - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE

MICHIGAN - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

MICHIGAN - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	**KEY DISEASE(S) AND WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL**	**SPECIFIC REASONS WHY METHYL BROMIDE IS NEEDED** *(e.g. Effective herbicide available, but not registered for this crop; mandatory requirement to meet certification for disease tolerance)*
Michigan	Soilborne fungal diseases: *Phytophthora capsici* and *Fusarium oxysporum*	No effective post-emergence control available; 1,3-D + chloropicrin is not feasible as a MB alternative due to regulatory and technical restrictions on use. Low soil temperatures and regulatory restriction also means that use of 1,3 D or metam sodium cannot be used with low soil temperatures. While a recent trial in Michigan indicated good yields when alternatives were used at higher soil temperatures, data were highly variable and the study needs to be repeated in larger plots before technical feasibility can be confirmed.

MICHIGAN - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

MICHIGAN - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	**MICHIGAN**
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Transplants grown for cucurbit fruit production.
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Corn, soybeans, tomatoes, strawberries, other cucurbit crops. MB is not used for the other crops if applied once already in a given year.
SOIL TYPES: *(Sand, loam, clay, etc.)*	Light to medium loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	Once every year for a given field
OTHER RELEVANT FACTORS:	Soil temperatures are low relative to the rest of the US cucurbit growing regions (see below)

MICHIGAN - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
CLIMATIC ZONE	Temperate USDA Plant Hardiness Zone 5b											
SOIL TEMP. *(℃)*	<10	10 - 15	15-20	20-25	20-25	20-25	20	10-15	<10	<10	<10	<10
RAINFALL *(mm)*	40	72	101	48	47	32	17	31	36	20	6	8
OUTSIDE TEMP. *(℃)*	0.2	7.4	12.1	17.5	20.6	20.9	18.1	8	2.4	-2.9	-8	-7
FUMIGATION SCHEDULE		X										
PLANTING SCHEDULE		X	X	X	X							
KEY MARKET WINDOW						X						

MICHIGAN – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Low soil temperatures (often below 10^{o} C) prior to the typical planting window inhibit dissipation of 1,3-D + chloropicrin (Martin, 2003), which can delay planting due to phytotoxicity to crop plants. There is also a 21-day planting delay as per registration label language. Combined, this results in a delay as long as 30 days in planting crops, which may negatively affect the economics of cucurbit production in this region. Metam sodium transformation into the active ingredient, methyl isothiocyanate, is also slowed by low soil temperatures (Ashley et al. 1963). Thus, optimal use of metam-sodium/potassium (even if effective against target pests) is likely to result in significant planting delays.

MICHIGAN - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

MICHIGAN - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	1998	1999	2000	2001	2002	2003
AREA TREATED *(hectares)*	417	427	508	567	589	224
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE IF STRIP TREATMENT IS USED	100% strip	100% strip	100% strip	100% strip	100% strip	100% strip
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kilograms)*	20,093	20,556	24,502	27,331	28,403	26,934
FORMULATIONS OF METHYL BROMIDE *(e.g. methyl bromide 98:2; methyl bromide /chloropicrin 70:30)*	67:33	67:33	67:33	67:33	67:33	67:33
METHOD BY WHICH METHYL BROMIDE APPLIED *(e.g. injected at 25cm depth, hot gas)*	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected
ACTUAL DOSAGE RATE OF ACTIVE INGREDIENT *(g/m^2)**	12.0	12.0	12.0	12.0	12.0	12.0

** Applications are made as strip treatments. Last year's application indicted a lower use rate that was incorrect.*

MICHIGAN - PART C: TECHNICAL VALIDATION

MICHIGAN - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

MICHIGAN – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
1,3 D + chloropicrin	In small plot trials conducted in Michigan, this formulation showed some efficacy against the key pests (Hausbeck and Cortright, 2003). Plant loss was about 6 % as compared to 0 % with MB. Perhaps more significantly, the average yield loss for the four cucurbit crops evaluated (zucchini, acorn squash, melons, and watermelons) was 44%, as compared to the MB standard. Furthermore, regulatory restrictions and Michigan's cool and wet soils result in a delay of up to 30 days in planting after treatment with this formulation. This results in growers missing key harvest windows, with consequent negative economic impacts (detailed in other sections below).	No
Metam-sodium (and metam potassium)	Control of the key pests is inconsistent at best. Trials with metam-potassium on small plots in Michigan showed yields of four cucurbit crops to be statistically similar to those obtained with MB (Hausbeck and Cortright, 2003). Another trial showed control of *Fusarium* in tomato, but this was performed in the much warmer conditions of southwest Florida (Webster et al., 2001). In the cool conditions of Michigan, metam-sodium is likely to be slow to transform into the active ingredient (methyl isothiocyanate), which suggests that pest control will not be as effective as in the more favorable Florida conditions. However, given the high variability of data in those trials, and the inconsistent results cited for tomato, it is not clear that this combination of alternatives will provide reliable pest management in the absence of MB.	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	Michigan's climate is typically cool (less than 11^{o} C frequently through May) and cloudy, particularly early in the growing season when control of the key pests is particularly important. In Michigan, the growing season is particularly short (May to September), so the time needed to utilize solarization is likely to render the subsequent growing of crops impossible, even if it did somehow eliminate all fungal pathogens.	No
Steam	While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in the open cucurbit crops in Michigan. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Biological Control	Biological control agents are not technically feasible alternatives to methyl bromide because they alone cannot control the soil pathogens that afflict cucurbits in Michigan. The bacterium *Burkholderia cepacia* and the fungus *Gliocladium virens* have shown some potential in controlling some fungal plant pathogens (Larkin and Fravel, 1998). However, in a test conducted by the Michigan applicants (included in the 2002 application from this region), *P. capsici* was not controlled adequately in summer squash, a cucurbit crop, by either of these beneficial microorganisms.	No
Cover crops and mulching	There is no evidence these practices effectively substitute for the control methyl bromide provides against *P. capsici.* Control of *P.capsici* is imperative for cucurbit production in Michigan. Plastic mulch is already in widespread use in Michigan vegetables, and regional crop experts state that it is not an adequate protectant when used without methyl bromide. The longevity and resistance of *P. capsici* oospores renders cover crops ineffective as a stand-alone management alternative to methyl bromide.	No
Crop rotation and fallow land	The crop rotations available to growers in Michigan region are also susceptible to these fungi, particularly to *P. capsici*. Fallow land can still harbor *P. capsici* oospores (Lamour and Hausbeck, 2003). Thus fungi would persist and attack cucurbits if crop rotation/fallow land was the main management regime.	No
Endophytes	Though these organisms (bacteria and fungi that grow symbiotically or as parasites within plants) apparently suppress some plant pathogens in cucumber (MBTOC, 1994), there is no such information for the other cucurbit crops grown in Michigan. Furthermore, the target pathogens of the study did not include *P. capsici*, probably the greatest threat to Michigan cucurbits.	No
Flooding/Water management	Flooding is not technically feasible as an alternative because it does not have any suppressive effect on *P. capsici* (Allen et al., 1999), and is likely to be impractical for Michigan cucurbit growers. It is unclear whether irrigation methods in this region could be adapted to incorporate flooding or alter water management for cucurbit fields. In any case, there appears to be no supporting evidence for its use against the hardy oospores of *P. capsici*.	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	Due to the paucity of scientific information on the utility of these alternatives as methyl bromide replacements in cucurbits, they have been grouped together for discussion in this document. There are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major cucurbit pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives for control of *Phytophthora* and *Fusarium* fungi. Soilless culture, organic production, and substrates/plug plants are also not technically viable alternatives to methyl bromide for fungi. One of the fungal pests listed by Michigan can spread through water (Gevens and Hausbeck, 2003), making it difficult to keep any sort of area (with or without soil) disease free. Various aspects of organic production – e.g., cover crops, fallow land, and steam sterilization - have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
COMBINATIONS OF ALTERNATIVES		
Metam sodium + Chloropicrin	Trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Locascio and Dickson, 1998; Csinos et al., 1999). Low efficacy in even small-plot trials indicates that this is not a technically feasible alternative for commercially produced cucurbits at this time. These studies apparently did not measure yield impacts, and did not involve cucurbits. Trials with metam-potassium + chloropicrin on small plots in Michigan showed yields of 4 cucurbit crops to be statistically similar to those obtained with MB (Hausbeck and Cortright, 2003). However, given the high variability of data in those trials, and the inconsistent results cited for tomato, it is not clear that this combination of alternatives will provide reliable pest management in the absence of MB.	No
1,3 D + Metam-sodium	Trials in tomato have shown inconsistent efficacy of this formulation against fungal pests, though it is generally better than metam-sodium alone (Csinos et al., 1999). Low efficacy in even small-plot trials indicates that this is not a technically feasible alternative for commercially produced cucurbits in Michigan at this time. These studies apparently did not measure yield impacts, and did not involve cucurbits. The study in Michigan mentioned for other alternatives (Hausbeck and Cortright, 2003) did not address this combination.	No

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

MICHIGAN - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

MICHIGAN – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Other than those options discussed elsewhere, no alternatives exist for the control of the key pests when they are present in the soil and/or afflict the belowground portions of cucurbit plants. A number of effective fungicides are available for treatment of these fungi when they infect aerial portions of crops. However, these infections are not the focus of MB use, which is meant to keep newly planted transplants free of these fungi.	

MICHIGAN - 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

MICHIGAN – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS *State if registered for this crop, registered for crop but use restricted, registered for other crops but not target crop, or not registered*	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	Not registered in the U.S. Registration is currently being pursued only for tomatoes, strawberries, peppers, and ornamental crops.	Not currently for cucumbers	Unknown
Furfural	Not registered in the U.S. for cucurbits. Registration is currently being pursued only for non-food greenhouse uses.	No (for cucurbits)	Unknown
Sodium azide	Not registered; no registration requests submitted to U.S.	No (for any crop/commodity)	Unknown
Propargyl bromide	Not registered; no registration requests submitted to U.S.	No (for any crop/commodity)	Unknown

MICHIGAN - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED

A field trial was conducted in small plots in 2003 in Michigan by Hausbeck and Cortright (2003) of Michigan State University. This study examined a number of vegetable crops including the cucurbits zucchini, acorn squash, and melons. Results, submitted with their 2004 CUE request, indicated that 1,3 D + 35 % chloropicrin treatments (shank-injected at 56.7 liters/ha) showed an average of 44% yield loss compared to MB (due to both *Phytophthora* and *Fusarium* combined). Chloropicrin alone (shank-injected at 233.6 l/ha) showed an average 15.5% loss compared to MB. Metam-potassium showed yields similar to those seen with MB. Metam-sodium was not tested, but can reasonably be assumed to be equivalent to metam-potassium (since the active ingredient is identical). Methyl iodide (currently unregistered for cucurbits) with 33% chloropicrin (shank-injected, at 36.8 kg/ha, respectively), also showed yields similar to that of MB. It should be noted that even large differences in average yields across various treatments were often not statistically significant, suggesting that there was high variability in the data.

In studies with other vegetable crops, 1, 3 D + chloropicrin has generally shown better control of fungi than metam-sodium formulations (though still not as good as control with MB). For example, in a study using a bell pepper/squash rotation in small plots, Webster et al. (2001) found significantly lower fungal populations with 1,3 D + 35 % chloropicrin (drip applied, 146 kg/ha of 1,3 D), as compared to the untreated control. However, MB (440 kg/ha, shank-injected) reduced fungal populations even more. It should be noted that *P. capsici* was not present in test plots, though *Fusarium* spp. were. Methyl iodide had no significant suppressive effect, as compared to the untreated control. However, neither of these MB alternatives increased squash fruit weight significantly over the untreated control. Indeed, as compared to the MB standard treatment plots, squash fruit weight was 63 % lower in the 1,3 D plots, and 41 % lower in the methyl iodide plots. The proportion of marketable squash fruit (defined only as those fruit so bad as to have to be discarded) in the 1,3 D plots was 30 % lower than that in the MB plots, though in the methyl iodide plots it was equivalent to MB.

In another study conducted on tomatoes, Gilreath et al. (1994) found that metam-sodium treatments did not match MB in terms of plant vigor at the end of the season; again, *Fusarium* (but not *P. capsici*) was one of several pests present.

Taken together, these studies indicate that, while the recent trials in Michigan are promising for the use of metam-sodium/potassium + chloropicrin, there is still great inconsistency in efficacy and protection from yield losses. Further, no large scale field trials have yet been performed to demonstrate reliable, consistent pest control similar to that of MB in the cucurbit growing regions of Michigan. Given the highly variable results with this MB alternative, EPA decided that the best case yield loss scenario would be a level similar to what was assessed in the 2003 Critical Use Nomination. Hence Table C.1 and the associated economic loss analyses (Part E) are based on the level used in that Nomination.

MICHIGAN – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
Metam-sodium/potassium + chloropicrin	Soil borne fungal diseases	0 - 30 % PLUS loss of revenue due to planting delays (Note: 0 % is plausible only in cases where the initial infestation of *Fusarium* is very low, and *P. capsici* is absent)	6 % plus loss of revenue due to planting delays (Hausbeck and Cortright, 2004)
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**6 % likely with the best alternative (metam-sodium/potassium))**

MICHIGAN - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

The critical use exemption applicant states that 1,3 D + chloropicrin, metam-sodium, furfural, propylene oxide, and sodium azide will continue to be the subjects of field studies of utilization and efficacy enhancement where *Phytophthora* and *Fusarium* fungi are the target pests. It should be kept in mind that furfural, propylene oxide, and sodium azide are currently unregistered for use on cucurbits, and there are presently no commercial entities pursuing registration in the U.S. The regulatory restrictions on 1,3 D discussed elsewhere will also remain as negative influences on the economics of this MB alternative. The timeline for developing the above-mentioned MB alternatives in Michigan (by Michigan State University) is as follows:

2003 – 2005: Test for efficacy (particularly against the more prevalent *Phytophthora* fungi)
2005 – 2007: Establish on-farm demonstration plots for effective MB alternatives
2008 – 2010: Work with growers to implement widespread commercial use of effective alternatives.

Research is also under way to optimize the use of a 50 % MB: 50 % chloropicrin formulation to replace the currently used 67:33 formulation. In addition, field research is being conducted to optimize a combination of crop rotation, raised crop beds, black plastic, and foliar fungicides. Use of virtually impermeable film (VIF) will also be investigated as a replacement for the currently used low density polyethylene (LDPE). All research is to be conducted by Michigan State University staff in collaboration with commercial cucurbit growers.

MICHIGAN - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?:

Research is ongoing in Michigan to find new technologies, chemicals, and application methods that will reduce the use of MB.

MICHIGAN - SUMMARY OF TECHNICAL FEASIBILITY

The U.S. EPA has determined that only metam potassium (with or without chloropicrin) has some technical feasibility against the key pests of cucurbits in this region. 1,3 D + chloropicrin, which has shown promise against these pests in trials in other regions and crops, did not provide control comparable to MB in new tests conducted in Michigan in 2003. Metam sodium/potassium has also been inconsistent across different studies, and no large-plot studies have been performed to show commercial feasibility in cucurbits (e.g., Martin 2003, Hausbeck and Cortright, 2003; Csinos et al., 1999). Important technical and regulatory constraints on both 1,3 D and metam-sodium/potassium formulations must also be considered: a 21 – 30 day planting delay, mandatory 100 foot buffers (for 1,3 D) near inhabited structures – both of which will cause negative economic impacts, and potentially lower dissipation (and thus efficacy) in the cool soils of this region.

Currently unregistered alternatives, such as furfural and sodium azide, have shown good efficacy against the key pests involved in small plot tests. However, even if registration is pursued soon (and the U.S. EPA has no indications of any commercial venture planning to do so), these options will need more research on how to adapt them to commercial cucurbit production in Michigan.

There are currently no non-chemical alternatives that are currently viable for MB replacement for commercial cucurbit growers. In sum, while the potential exists for a combination of chemical and non-chemical alternatives to replace MB use in Michigan cucurbits, analysis ongoing research will help determine the timeline of transition from MB to alternatives.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST*:*

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	**KEY DISEASE(S) AND WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL**	**SPECIFIC REASONS WHY METHYL BROMIDE NEEDED** *(e.g. Effective herbicide available, but not registered for this crop; mandatory requirement to meet certification for disease tolerance)*
"Southeastern U.S. (except Georgia)". A consortium of cucurbit growers in Alabama, Arkansas, Kentucky, Louisiana, North Carolina, South Carolina, Tennessee, and Virginia is included here	Nutsedges: yellow (*Cyperus esculentus*), and purple (*Cyperus rotundus*); to a lesser extent: fungal diseases (*Phytophthora*, *Fusarium* spp.) and root knot nematodes (*Meloidogyne incognita*)	No effective alternatives exist for control of the nutsedge, due to either lack of registration, planting delays (due to regulatory restriction or phytotoxicity) or low efficacy, or lack of registration of potentially effective herbicides, all of which result in significant economic loss. In part of this region, fungal diseases may also have no effective control in the absence of MB, due to regulatory restrictions and planting delays associated with 1,3 D + chloropicrin use.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	**SOUTHEASTERN U.S. (EXCEPT GEORGIA)**
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Transplants grown for cucurbit fruit production.
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Other cucurbits, tobacco, grains, cotton
SOIL TYPES: *(Sand, loam, clay, etc.)*	Low organic content, light to medium loam
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	Once every year
OTHER RELEVANT FACTORS:	

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
CLIMATIC ZONE	Temperate USDA Plant Hardiness Zones 6b – 8b											
SOIL TEMP. *(℃)*	Not available.											
RAINFALL *(mm)*	163	124	109	87	78	146	113	202	109	116	54	76
OUTSIDE TEMP. *(℃)*	9.4	14.5	17.7	23.4	26	25.9	22.6	14.9	7.7	3.4	2.9	4.2
FUMIGATION SCHEDULE	X	X										X
PLANTING SCHEDULE	X	X	X		X	X						
KEY MARKET WINDOW							X					

SOUTHEASTERN U.S. (EXCEPT GEORGIA) – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Alternatives have not been effective against some of the key pests in this sector in certain areas of the southeastern U.S.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
AREA TREATED *(hectares)*	3,541	3,976	4,532	5,034	5,253	5,658
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE IF STRIP TREATMENT IS USED	Strip beds	Strip beds	Strip beds	Strip beds	Strip beds	Strip beds
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kg)*	777,910	597,177	680,751	756,120	788,942	849,723
FORMULATIONS OF METHYL BROMIDE *(e.g. methyl bromide 98:2; methyl bromide /chloropicrin 70:30)*	98:2	67:33	67:33	67:33	67:33	67:33
METHOD BY WHICH METHYL BROMIDE APPLIED *(e.g. injected at 25cm depth, hot gas)*	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected
ACTUAL DOSAGE RATE OF ACTIVE INGREDIENT *(g/m^2)* *****	22.0	15.0	15.5	15.0	15.0	15.0

** Applications are made as strip treatments.*

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - PART C: TECHNICAL VALIDATION

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

SOUTHEASTERN U.S. (EXCEPT GEORGIA) – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
1,3 D + chloropicrin	Effective (in small plot studies) in controlling disease and nematode pests, but not nutsedges (Locascio et al., 1997; Csinos et al., 1999; Noling et al., 2000). Subject to regulatory restrictions in some areas (where Karst geology exists).	No
Metam-sodium	Provides control of nutsedges only close to application site (Dowler, 1999; Locascio and Dickson, 1998). Surviving nutsedge tubers can potentially recolonize the crop field (Webster, 2002). Not effective against the disease or nematode pests in this region. Approximate yield losses due to nutsedge are 3 – 25 %; losses would be higher in areas facing the other key pests along with nutsedges. Technically and economically infeasible due to these yield losses (see economic analyses in Part E)	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	For nutsedge control in the southeastern U.S. states, solarization is unlikely to be technically feasible as a methyl bromide alternative. Research indicates that the lethal temperature for nutsedge tubers is 50^o C or higher (Chase et al., 1999). While this may be achieved for some portion of the autumn cropping in southern cucurbit growing regions, it is very unlikely for any portion of the spring crops. Trials conducted in mid-summer in Georgia resulted in maximal soil temperatures of 43^o C at 5 cm depth. Thus, solarization, even in the warmer months in southern states, did not result in temperatures reliably high enough to destroy nutsedge tubers, and tubers lodged deeper in the soil would be completely unaffected.	No
Steam	Steam is not a technically feasible alternative for open field cucurbit production because it requires sustained heat over a required period of time (UNEP, 1998). While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open cucurbit crops. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Biological Control	Biological control agents are not technically feasible alternatives to methyl bromide because they alone cannot control the soil pathogens and/or nutsedges that afflict cucurbits. While some fungal pathogens showed potential as control agents (Phatak, 1983), no work has yet been done on using these pathogens as reliable pest management tools in open-field cucurbit crops. Season-long field tests have shown low levels of pest control or lack of persistence of the control agents (Kadir et al., 2000)	No
Cover crops and mulching	Cover crops and mulches appear to control many weeds, but not nutsedges (Burgos and Talbert, 1996). The effect of cover crops on cucurbit crop growth and yield remains unknown; this contributes to the technical obstacles this strategy faces as a methyl bromide alternative. In some studies cover crops have delayed crop maturity and reduced height and yield of plants (Burgos and Talbert, 1996, Galloway and Weston, 1996). Mulching has also been shown to be ineffective in controlling nutsedges, since these plants are able to penetrate through both organic and plastic mulches (Munn, 1992; Patterson, 1998).	No
Crop rotation and fallow land	Crop rotation/fallow is not a technically feasible alternative to methyl bromide because it does not, by itself, provide adequate control of fungi or nutsedges. The crop rotations available to growers are also susceptible to fungi; fallow land can still harbor fungal oospores (Lamour and Hausbeck, 2003). As regards nutsedges, tubers of these perennial species provide new plants with larger energy reserves than the annual weeds that can be frequently controlled by crop rotations and fallow land (Thullen and Keeley, 1975). Furthermore, nutsedge plants can produce tubers within 2 weeks after emergence (Wilen et al., 2003). This enhances their survival across different cropping regimes that can disrupt other plants that rely on a longer undisturbed growing period to produce seeds to propagate the next generation.	No
Endophytes	Though these organisms (bacteria and fungi that grow symbiotically or as parasites within plants) have shown potential against some pathogens in cucumber (MBTOC, 1994), there is no such information for the other cucurbit crops. Similarly, the U.S. found no evidence that endophytes control nutsedges	No

NAME OF ALTERNATIVE	**TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS**	**IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?**
Flooding/Water management	As with many of the other alternatives to methyl bromide, flooding has been shown to control a number of weeds, but not nutsedge species. Nutsedge is much more tolerant of watery conditions than many other weed pests. For example, Horowitz (1972) showed that submerging nutsedge in flowing or stagnant water (for 8 days and 4 weeks, respectively) did not affect the sprouting capacity of tubers. Another practical obstacle to implementing flood management approaches in cucurbit production in the southern and southeastern U.S. states is that the soil composition may not support flooding and still remain productive.	No
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	The U.S. was unable to locate any studies showing any potential for grafting, resistant rootstock or plant breeding as technically feasible alternatives to methyl bromide control of nutsedges in cucurbits. While in theory plant breeding may improve the ability of cucurbits to compete with these weeds for nutrients, light, etc., it would certainly not provide alternatives within the time span considered in this critical use exemption nomination. The effect on the quality of the crops involved is unknown also. For resistant rootstock at least, there are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major cucurbit pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives. US-EPA found no evidence that soilless culture or substrates/plug plants can be used to produce cucurbit crops on a large scale, or that they will control nutsedges, which like soil fungi are particularly hardy. Various aspects of organic production – organic mulches, cover crops, fallow land, steam sterilization have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
COMBINATIONS OF ALTERNATIVES		
Metam sodium + Chloropicrin	Would possibly be more effective than metam-sodium alone where fungal pests are the only concern (see Michigan sections for more discussion), but this combination may not prevent yield losses due to nutsedges, particularly where the weed pressure is high. U.S. EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al., 1999).	No
1,3 D + Metam-sodium	Controls nematodes but not nutsedges. U.S. EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al., 1999). Inconsistently effective against fungal pests (see Michigan sections for more discussion). 1,3-D also subject to regulatory prohibition of use on Karst geology (prevalent in Kentucky).	No

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration.*

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

SOUTHEASTERN U.S. (EXCEPT GEORGIA) – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Halosulfuron-methyl	Herbicide: causes potential crop injury; has plant back restrictions. Efficacy is lowered in rainy conditions (common during the period of initial planting of these crops). Also, a 24-month plant back restriction may cause significant economic disruption if growers must rely on this control option. Halosulfuron is only allowed for the row middles for cucurbits, due to its phytotoxicity. This would result in nutsedges surviving close to crop plants. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.
Glyphosate	Herbicide: Is non-selective; like halosulfuron, it will not control nutsedge within the plant rows; does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.
Paraquat	Herbicide: Is non-selective; will not control nutsedge in the plant rows; does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

SOUTHEASTERN U.S. (EXCEPT GEORGIA) – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	For nutsedges and fungi: Not registered in the USA for cucurbits. Registration is currently being pursued only for tomatoes, strawberries, peppers, and ornamental crops	No (for cucurbits)	N/A
Pebulate	For nutsedges: Was registered for use in tomatoes only, but even this registration lapsed December 31, 2002 (registrant corporation went out of business)	No (for cucurbits)	N/A
S-metolachlor	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Terbacil	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Rimsulfuron	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Trifloxysulfuron	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED

For a discussion of relative effectiveness of MB alternatives against fungal pests, please see Section 16 for the Michigan region. Few studies have specifically targeted cucurbits for alternatives to MB. In the southeastern U.S., both metam-sodium and 1,3 D + 35 % chloropicrin have shown good efficacy against root knot nematodes, in trials with tomato and pepper. For example, Locascio and Dickson (1998) reported that metam-sodium + 35 % chloropicrin (295 l/ha of metam-sodium, shank-injected) reduced nematode galls significantly over untreated control plots, though not as much as did MB + 35 % chloropicrin treatments (500kg MB/ha, shank-injected), in Florida tomatoes. Analysis of 35 tomato and 5 pepper trials conducted from 1993 – 1995 indicated that 1,3 D (with either 17 % or 35 % chloropicrin) provided control of nematodes that was equal or superior to that seen with MB, in 95 % of the tomato and 100 % of pepper trials (Eger, 2000). However, it is not clear whether yields were also comparable to those obtained with MB. Noling et al (2000) also studied the effects of metam-sodium (115 l/ha, syringe-injected), 1,3 D + 17 % chloropicrin (53.6 l/ha, soil-injected), and 1,3 D + 35 % chloropicrin (39.8 l/ha), among other treatments, in tomato plots. Galls inflicted by root knot nematodes were reduced significantly by all these MB alternatives, as compared to untreated control plots. Yields were also significantly higher as compared to the control plots; all MB alternatives resulted in similar high yields. However, the effects of MB formulations were not reported in this study. Further, it is the opinion of some US crop experts that metam sodium, in particular, is very inconsistent in its beneficial effects as a nematode control agent (Dr. S. Culpepper, University of Georgia, personal communication).

For nutsedges, metam-sodium and 1,3 D (with and without chloropicrin) have shown inconsistent efficacy that is often inferior to that of MB formulations. For example, Locascio et al. (1997) studied MB alternatives on tomatoes grown in small plots in Florida. Various treatments were tested on plots that had multiple pests. At the Bradenton site there was moderate to heavy *Fusarium* infestation; heavy purple nutsedge infestation and light root-knot nematode pressure. At Gainesville there was heavy infestation of yellow and purple nutsedge and moderate infestation of root-knot nematode. The treatments at both locations included MB (67%) + chloropicrin (33%) chisel-injected at 390 kg/ha; metam-sodium (chisel-injected) at 300L/ha; metam-sodium drip-irrigated at 300L/ha; and 1,3-D + 17% chloropicrin chisel-injected at 327L/ha. In pair wise statistical comparisons, the yield was significantly lower in metam-sodium treatments compared to MB at both sites. At Bradenton, the average yield from both metam-sodium treatments was 33% of the MB yields, suggesting a 67% yield loss from not using MB. At Gainesville, the average yield of the two metam-sodium treatments was 56% of the MB yield, suggesting a 44% yield loss from not using MB. The yield of the 1,3-D treatment at Gainesville was 71% of the MB standard suggesting a 29% loss by not using MB (yield data for 1,3-D were not reported for Bradenton). In considering 1,3 D results, the reader must keep in mind that this MB alternative cannot be used in areas where karst geology exists. No farm scale trials appear to have been done to validate these results as yet.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 D + chloropicrin	Nutsedges	10-40 % (for areas included in this request)	29 % (Locascio, et al., 1997)
Metam-sodium (with or without chloropicrin)	Nutsedges	10-66 % (for areas included in this request)	44 % (Locascio, et al., 1997)
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**29 % where 1,3 D can be used; 44 % where only metam sodium can be used**

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

The applicant states that research has been conducted on nutsedge control with halosulfuron, 1,3 D + chloropicrin, and metam-sodium. Future research will focus on halosulfuron and crop rotation for control of nutsedges. Approximately 3 to 5 years are expected as a timeframe for developing effective MB alternatives for nutsedge control in cucurbits produced in this region. Research will be conducted in cooperation with commercial cucurbit growers, by faculty and extension staff at various land-grant universities in the states encompassed by this region. Also, it is reasonable to expect that the results from Michigan research on fungicidal alternatives to MB will be used to develop options for fungal pests of southeastern US cucurbits.

Future plans to minimize MB use also include:

(1) Using research and on-farm evaluations optimize a combination of nutsedge control in fallow fields, crop rotation, and use of post-emergent herbicide in crops. Herbicides will include halosulfuron, sulfentrazone, and glyphosate.
(2) Optimize the combined use of plastic (e.g., LDPE) tarps and drip irrigation equipment for applying at-plant herbicides.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?:

No. Areas where MB is not used in this region do not face moderate to severe populations of the key pests.

SOUTHEASTERN U.S. (EXCEPT GEORGIA) - SUMMARY OF TECHNICAL FEASIBILITY

As regards the key pests cited by the applicants from this region, technically feasible alternatives appear to exist for root knot nematodes, namely 1,3 D + chloropicrin and metam-sodium (by itself or with chloropicrin). 1, 3 D + chloropicrin also shows efficacy against the fungal pests in this region. However, this MB alternative has significant regulatory and technical limitations that are likely to result in negative economic impacts (please see the summary of technical feasibility for Michigan for a discussion of these limitations). In addition to the limitations faced by Michigan growers, farmers in the southeastern USA who farm on Karst geology are prohibited from even considering this option due to regulatory restrictions intended to mitigate groundwater contamination. When 1,3 D cannot be used, growers in this region will have no technically feasible control option where fungi are the major pests.

For nutsedge pests, which are widespread in this region, cucurbit growers do not currently have technically feasible alternatives to MB use at planting. Metam-sodium and 1,3 D + chloropicrin have shown some efficacy in small-plot trials in other vegetable crops (e.g, tomato). However, at best, metam sodium may allow at least 44 % yield loss, while 1,3 D may allow at least 29 % loss. Both often show less control than MB (in terms of population suppression) of nutsedges. These factors suggest that even this alternative will not be economically feasible even in the best-case technical scenario. It should be noted that there is evidence that both 1,3 D and methyl isothiocynate levels decline more rapidly, thus further compromising efficacy, in areas where these are repeatedly applied (Smelt et al., 1989; Ou et al., 1995; Gamliel et al., 2003). This is due to enhanced degradation of these chemicals by soil microbes (Dungan and Yates, 2003).
Other chemical alternatives to MB that have shown promise against nutsedges (e.g, pebulate) are currently unregistered for cucurbits, and are often not being developed for registration by any commercial entity.

In a new study, Culpepper and Langston (2004) conducted studies at 2 sites in spring 2003 and 1 site in fall 2004. Plot sizes were 20 feet X 32 inches (4.94 m^2). Treatments were: Methyl bromide standard (67:33 formulation), untreated control, 2 formulations of telone (1,3 D + chloropicrin) at various doses, followed by an additional application of either chloropicrin or metam-sodium, a third formulation of 1,3 D + chloropicrin (“Inline”), and methyl iodide. An additional set of plots received the same fumigant treatments but also received an herbicide treatment (clomazone + halosulfuron) later in the season.

Watermelon – the only cucurbit crop addressed in these experiments – showed no significant (final) yield differences across any fumigant treatment. The same lack of difference was observed when herbicides were added. In fact, there was no difference in yield even when pesticide treatments were compared to the untreated control. However, nutsedge populations in the study appeared to be relatively low (e.g., 667 plants per plot or $135/m^2$, in the untreated control, at the end of the study).

Furthermore, a number of important caveats must be mentioned when considering these results:

(1) Plots used were quite small, and it is not at all clear if the promising results will hold reliably in larger commercial fields. This is particularly worrisome given the highly variable results reported by other researchers for the same MB alternatives.

(2) The nutsedge populations in this study were dominated by yellow nutsedge (90 % of the total number). It is not clear if populations where purple nutsedge is dominant will be controlled as effectively. A number of other studies have indicated that purple nutsedge is a hardier species, and even in Culpepper and Langston's study, it appeared more resistant to the MB alternatives. For example, methyl iodide gave "77 % control" of yellow nutsedge, but only "37 % control" of purple nutsedge. Control in this case was apparently defined as the reduction in nutsedge populations as compared to populations in the untreated control.

(3) This study was done only with watermelons, and it is not clear if other cucurbits will respond so favorably in terms of yield, or lack of phytotoxic response. Also, a custom-built applicator had to be used for the metam-sodium applications to eliminate worker exposure risks, according to the authors. It is not yet clear if such an applicator can be mass-produced and/or used reliably in a commercial setting.

The other key pest cited for cucurbits in this region, *Pythium* rot, was not examined in this study. Thus these results do not shed additional light on whether alternative soil fumigants could be used against that pest.

Large-scale, on-farm demonstrations of optimal application methodology in a commercial setting are lacking for cucurbit crops, adding to the current lack of viability of MB alternatives in this crop system. While a combination of alternatives may replace MB in future cucurbit production in this region, it remains some years away from technical feasibility.

GEORGIA - PART B: CROP CHARACTERISTICS AND METHYL BROMIDE USE

GEORGIA – 10. KEY DISEASES AND WEEDS FOR WHICH METHYL BROMIDE IS REQUESTED AND SPECIFIC REASONS FOR THIS REQUEST

GEORGIA - TABLE 10.1: KEY DISEASES AND WEEDS AND REASON FOR METHYL BROMIDE REQUEST

REGION WHERE METHYL BROMIDE USE IS REQUESTED	**KEY DISEASE(S) AND WEED(S) TO GENUS AND, IF KNOWN, TO SPECIES LEVEL**	**SPECIFIC REASONS WHY METHYL BROMIDE NEEDED** *(e.g. Effective herbicide available, but not registered for this crop; mandatory requirement to meet certification for disease tolerance)*
Georgia	Nutsedges: yellow (*Cyperus esculentus*), and purple (*Cyperus rotundus*); fungal diseases (mainly *Pythium* spp.); to a lesser extent: root knot nematodes (*Meloidogyne incognita*)	No effective alternatives exist for control of the nutsedge, due to either lack of registration, planting delays (due to regulatory restriction or phytotoxicity) or low efficacy, both of result in significant economic loss, or lack of registration of potentially effective herbicides. In part of this region**,** fungal diseases may also have no effective control in the absence of MB, due to regulatory restrictions on the only effective alternative (1,3 D + chloropicrin). Georgia may have a higher level of nematode pressure than the other southeastern states.

GEORGIA - 11. (*i*) CHARACTERISTICS OF CROPPING SYSTEM AND CLIMATE

GEORGIA - TABLE 11.1: CHARACTERISTICS OF CROPPING SYSTEM

CHARACTERISTICS	**GEORGIA**
CROP TYPE: *(e.g. transplants, bulbs, trees or cuttings)*	Transplants grown for cucurbit fruit production.
ANNUAL OR PERENNIAL CROP: *(# of years between replanting)*	Annual (one)
TYPICAL CROP ROTATION *(if any)* **AND USE OF METHYL BROMIDE FOR OTHER CROPS IN THE ROTATION:** *(if any)*	Other cucurbits, bell pepper, squash, eggplant
SOIL TYPES: *(Sand, loam, clay, etc.)*	Light to medium loam, low organic matter
FREQUENCY OF METHYL BROMIDE FUMIGATION: *(e.g. every two years)*	Once every year
OTHER RELEVANT FACTORS:	Karst geology are widespread in Georgia.

GEORGIA - TABLE 11.2 CHARACTERISTICS OF CLIMATE AND CROP SCHEDULE

	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB
CLIMATIC ZONE	Temperate USDA Plant Hardiness Zones 7a – 8b											
SOIL TEMP. *(℃)*	**Applicant is requested to supply any available data**											
RAINFALL *(mm)*	206	108	148	248	0	158	84	122	109	137	37	131
OUTSIDE TEMP. *(℃)*	15	17.7	22.9	25.6	27.2	27.5	25.1	20	11.4	7.5	6.2	9.7
FUMIGATION SCHEDULE					X							X*
PLANTING SCHEDULE	X				X	X						
KEY MARKET WINDOW						X**				X**		

Notes:

(1) * = This fumigation period is for a cantaloupe typically double cropped with squash, which is typically a spring application cycle; the other fumigation period shown is for cucumber usually double cropped with bell peer and squash usually double cropped with cabbage, both typically a fall cycle.

(2) ** = US-EPA assumes these are the key market windows based on harvest schedule supplied by the applicant. According to the applicant, harvests for fall cycle crops occur in October & November, those for spring cycle crops occur in May through July.

(3) Planting schedule is July and August for crops with a fall application cycle; March for those with a spring cycle.

GEORGIA – 11. (*ii*) INDICATE IF ANY OF THE ABOVE CHARACTERISTICS IN 11. (*i*) PREVENT THE UPTAKE OF ANY RELEVANT ALTERNATIVES?

Karst geology prevent widespread application of 1,3 D + chloropicrin as an alternative for disease and nematode control, because regulatory restrictions prohibit use of this chemical on the overlying soils.

GEORGIA - 12. HISTORIC PATTERN OF USE OF METHYL BROMIDE, AND/OR MIXTURES CONTAINING METHYL BROMIDE, FOR WHICH AN EXEMPTION IS REQUESTED

GEORGIA - TABLE 12.1 HISTORIC PATTERN OF USE OF METHYL BROMIDE

FOR AS MANY YEARS AS POSSIBLE AS SHOWN SPECIFY:	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
AREA TREATED *(hectares)*	1,873	2,408	2,062	2,872	2,767	2,932
RATIO OF FLAT FUMIGATION METHYL BROMIDE USE TO STRIP/BED USE IF STRIP TREATMENT IS USED	100% Strip	100% Strip	100% Strip	100% Strip	100% Strip	100% Strip
AMOUNT OF METHYL BROMIDE ACTIVE INGREDIENT USED *(total kg)*	462,779	449,691	317,177	431,487	415,624	440,357
FORMULATIONS OF METHYL BROMIDE *(e.g. methyl bromide 98:2; methyl bromide/Chloropicrin 70:30)*	98:2	67:33	67:33	67:33	67:33	67:33
METHOD BY WHICH METHYL BROMIDE APPLIED *(e.g. injected at 25cm depth, hot gas)*	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected	Shank injected
ACTUAL DOSAGE RATE OF ACTIVE INGREDIENT *(g/m^2)****	24.7	19.1	15.4	15.0	15.0	15.0

** Applications are made as strip treatments.*

GEORGIA - PART C: TECHNICAL VALIDATION

GEORGIA - 13. REASON FOR ALTERNATIVES NOT BEING FEASIBLE

GEORGIA – TABLE 13.1: REASON FOR ALTERNATIVES NOT BEING FEASIBLE

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
CHEMICAL ALTERNATIVES		
1,3 D + chloropicrin	Effective (in small plot studies) in controlling disease and nematode pests, but control of nutsedges is inconsistent at best (Locascio et al., 1997; Csinos et al., 1999; Noling et al., 2000; Culpepper and Langston, 2004). Subject to regulatory restrictions in some areas (where Karst geology exist).	No
Metam-sodium	Provides control of nutsedges only close to application site (Dowler, 1999; Locascio and Dickson, 1998). Surviving nutsedge tubers can recolonize the crop field (Webster, 2002). Not effective against the disease or nematode pests in this region. Approximate yield losses due to nutsedge are 3-66%; losses would be higher in areas facing the other key pests along with nutsedges. This alternative is both not feasible due to these yield losses.	No
NON CHEMICAL ALTERNATIVES		
Soil solarization	For nutsedge control in the southeastern U.S. states, solarization is unlikely to be technically feasible as a methyl bromide alternative. Research indicates that the lethal temperature for nutsedge tubers is 50^{o} C or higher (Chase et al., 1999). While this may be achieved for some portion of the autumn cropping in southern cucurbit growing regions, it is very unlikely for any portion of the spring crops. Trials conducted in mid-summer in Georgia resulted in maximal soil temperatures of 43^{o} C at 5 cm depth. Thus, solarization, even in the warmer months in southern states, did not result in temperatures reliably high enough to destroy nutsedge tubers, and tubers lodged deeper in the soil would be completely unaffected.	No
Steam	Steam is not a technically feasible alternative for open field cucurbit production because it requires sustained heat over a required period of time (UNEP, 1998). While steam has been used effectively against fungal pests in protected production systems, such as greenhouses, there is no evidence that it would be effective in open cucurbit crops. Any such system would also require large amounts of energy and water to provide sufficient steam necessary to sterilize soil down to the rooting depth of field crops (at least 20-50 cm).	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Biological Control	Biological control agents are not technically feasible alternatives to methyl bromide because they alone cannot control the soil pathogens and/or nutsedges that afflict cucurbits. While some fungal pathogens showed potential as control agents (Phatak, 1983), no work has yet been done on using these pathogens as reliable pest management tools in open-field cucurbit crops. Season-long field tests have shown low levels of pest control or lack of persistence of the control agents (Kadir et al., 2000)	No
Cover crops and mulching	Cover crops and mulches appear to control many weeds, but not nutsedges (Burgos and Talbert,1996). The effect of cover crops on cucurbit crop growth and yield remains unknown; this contributes to the technical obstacles this strategy faces as a methyl bromide alternative. In some studies cover crops have delayed crop maturity and reduced height and yield of plants (Burgos and Talbert, 1996; Galloway and Weston, 1996). Mulching has also been shown to be ineffective in controlling nutsedges, since these plants are able to penetrate through both organic and plastic mulches (Munn, 1992; Patterson, 1998).	No
Crop rotation and fallow land	Crop rotation/fallow is not a technically feasible alternative to methyl bromide because it does not, by itself, provide adequate control of fungi or nutsedges. The crop rotations available to growers are also susceptible to fungi; fallow land can still harbor fungal oospores. As regards nutsedges, tubers of these perennial species provide new plants with larger energy reserves than the annual weeds that can be frequently controlled by crop rotations and fallow land. Furthermore, nutsedge plants can produce tubers within 8 weeks after emergence. This enhances their survival across different cropping regimes that can disrupt other plants that rely on a longer undisturbed growing period to produce seeds to propagate the next generation.	No
Endophytes	Though these organisms (fungi that grow symbiotically or as parasites within plants) have been shown to suppress some plant pathogens in cucumber, there is no such information for the other cucurbit crops. Similarly, the U.S. found no evidence that endophytes control nutsedges	No
Flooding/Water management	As with many of the other alternatives to methyl bromide, flooding has been shown to control a number of weeds, but not nutsedge species. Nutsedge is much more tolerant of watery conditions than many other weed pests. For example, Horowitz (1972) showed that submerging nutsedge in flowing or stagnant water (for 8 days and 4 weeks, respectively) did not affect the sprouting capacity of tubers. Another practical obstacle to implementing flood management approaches in cucurbit production in the southern and southeastern U.S. states is that the soil composition may not support flooding and still remain productive.	No

NAME OF ALTERNATIVE	TECHNICAL AND REGULATORY* REASONS FOR THE ALTERNATIVE NOT BEING FEASIBLE OR AVAILABLE + CITATIONS	IS THE ALTERNATIVE CONSIDERED COST EFFECTIVE?
Grafting/resistant rootstock/plant breeding/soilless culture/organic production/substrates/plug plants.	The U.S. was unable to locate any studies showing any potential for grafting, resistant rootstock or plant breeding as technically feasible alternatives to methyl bromide control of nutsedges in cucurbits. While in theory plant breeding may improve the ability of cucurbits to compete with these weeds for nutrients, light, etc., it would certainly not provide alternatives within the time span considered in this critical use exemption nomination. The effect on the quality of the crops involved is unknown also. For resistant rootstock at least, there are no studies documenting the commercial availability of resistant rootstock immune to the fungal pathogens listed as major cucurbit pests. Grafting and plant breeding are thus also rendered technically infeasible as methyl bromide alternatives. The U.S. found no evidence that soilless culture or substrates/plug plants can be used to produce cucurbit crops on a large scale, or that they will control nutsedges, which like soil fungi are particularly hardy. Various aspects of organic production – organic mulches, cover crops, fallow land, steam sterilization have already been addressed in this document and assessed to be technically infeasible methyl bromide alternatives.	No
COMBINATIONS OF ALTERNATIVES		
Metam sodium + Chloropicrin	Would be more effective than metam-sodium alone where fungal pests are the only concern (see Michigan sections for more discussion), but this combination may not prevent yield losses due to nutsedges, particularly where the weed pressure is high. U.S. EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al., 1999). Not feasible due to yield losses (see economic analyses elsewhere)	No
1,3 D + Metam-sodium	Controls nematodes but not nutsedges. US-EPA is aware of one vegetable study that showed control of yellow nutsedge with this chemical combination, but weed pressure in that small plot test was low, according to the authors (Csinos et al., 1999). Inconsistently effective against fungal pests (see Michigan sections for more discussion). 1,3-D also subject to regulatory prohibition of use on Karst geology (prevalent in Kentucky).	No

** Regulatory reasons include local restrictions (e.g. occupational health and safety, local environmental regulations) and lack of registration..*

GEORGIA - 14. LIST AND DISCUSS WHY REGISTERED *(and Potential)* PESTICIDES AND HERBICIDES ARE CONSIDERED NOT EFFECTIVE AS TECHNICAL ALTERNATIVES TO METHYL BROMIDE:

GEORGIA – TABLE 14.1: TECHNICALLY INFEASIBLE ALTERNATIVES DISCUSSION

NAME OF ALTERNATIVE	DISCUSSION
Halosulfuron-methyl	For nutsedges: potential crop injury; plant back restrictions. Efficacy is lowered in rainy conditions (common during the period of initial planting of these crops). Also, a 24-month plant back restriction may cause significant economic disruption if growers must rely on this control option. Halosulfuron is only allowed on the row middles for cucurbits, due to its phytotoxicity. This would result in weeds surviving close to crop plants. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.
Glyphosate	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.
Paraquat	For nutsedges: Non-selective; will not control nutsedge in the plant rows; does not provide residual control. Thus this herbicide is not technically feasible as a stand-alone replacement for MB, and its use in conjunction with other pest management methods has not yet been investigated.

GEORGIA - 15. LIST PRESENT *(and Possible Future)* REGISTRATION STATUS OF ANY CURRENT AND POTENTIAL ALTERNATIVES:

GEORGIA – TABLE 15.1: PRESENT REGISTRATION STATUS OF ALTERNATIVES

NAME OF ALTERNATIVE	PRESENT REGISTRATION STATUS *State if registered for this crop, registered for crop but use restricted, registered for other crops but not target crop, or not registered*	REGISTRATION BEING CONSIDERED BY NATIONAL AUTHORITIES? (Y/N)	DATE OF POSSIBLE FUTURE REGISTRATION:
Methyl iodide	For nutsedges: Not registered in the USA for cucurbits. Registration is currently being pursued only for tomatoes, strawberries, peppers, and ornamental crops	No (for cucurbits)	N/A
Pebulate	For nutsedges: Was registered for use in tomatoes only, but even this registration lapsed December 31, 2002 (registrant corporation went out of business)	No (for cucurbits)	N/A
S-metolachlor	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Terbacil	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Rimsulfuron	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A
Trifloxysulfuron	For nutsedges: registered for crops other than cucurbits	No (for cucurbits)	N/A

GEORGIA - 16. STATE RELATIVE EFFECTIVENESS OF RELEVANT ALTERNATIVES COMPARED TO METHYL BROMIDE FOR THE SPECIFIC KEY TARGET PESTS AND WEEDS FOR WHICH IT IS BEING REQUESTED

For a discussion of relative effectiveness of MB alternatives against fungal pests, please see Section 16 for the Michigan region. Though the fungal pest cited by Georgia growers is in a different genus (*Pythium*), the relative effectiveness of relevant MB alternatives is likely to be similar to that where the other soil borne fungal pests are concerned. For a discussion of relative effectiveness of MB alternatives against root knot nematodes and nutsedges, please see Section 16 for the Southeastern U.S. region.

GEORGIA – TABLE C.1: ALTERNATIVES YIELD LOSS DATA SUMMARY

ALTERNATIVE	LIST TYPE OF PEST	RANGE OF YIELD LOSS	BEST ESTIMATE OF YIELD LOSS
1,3 D + chloropicrin	Nutsedges	10-40 % (for areas included in this request)	29 % (Locascio et al., 1997)
Metam-sodium (with or without chloropicrin)	Nutsedges	10-66 % (for areas included in this request)	44 % (Locascio et al., 1997)
OVERALL LOSS ESTIMATE FOR ALL ALTERNATIVES TO PESTS			**29 % where 1,3 D can be used; 44 % where only metam sodium can be used**

GEORGIA - 17. ARE THERE ANY OTHER POTENTIAL ALTERNATIVES UNDER DEVELOPMENT WHICH ARE BEING CONSIDERED TO REPLACE METHYL BROMIDE?

For Georgia cucurbits, research focusing on the deployment of MB alternatives for control of nutsedges and *Phytophthora* fungi is planned. Field trials will include treatments with methyl iodide in combination with halosulfuron, 1,3 D in combination with chloropicrin and halosulfuron, and a combination of metam-potassium, 1,3 D, and halosulfuron. The Georgia applicants provided no specific timeline for development and deployment, but it is reasonable to expect that the 3-5 year timeframe cited by cucurbit growers in the other southeastern US states will probably apply. University of Georgia research and extension staff will conduct trials, presumably in collaboration with cooperating growers.

Future plans to minimize MB use also include:

> (1) Using research and on-farm evaluations optimize a combination of nutsedge control in fallow fields, crop rotation, and use of post-emergent herbicides in crops. Herbicides will include halosulfuron, sulfentrazone, and glyphosate.
> (2) Optimize the combined use of plastic (LDPE) tarps and drip irrigation equipment for applying at-plant herbicides.

It is also reasonable to expect that growers in this region will adopt measure shown in Michigan to be successful in minimizing MB use where fungal pests are the only key pests involved.

GEORGIA - 18. ARE THERE TECHNOLOGIES BEING USED TO PRODUCE THE CROP WHICH AVOID THE NEED FOR METHYL BROMIDE?:

No. Areas where MB is not used in this region do not face moderate to severe populations of the key pests.

GEORGIA - SUMMARY OF TECHNICAL FEASIBILITY

As regards the key pests cited by the applicants from this region, technically feasible alternatives appear to exist for root knot nematodes, namely 1,3 D + chloropicrin and metam-sodium (by itself or with chloropicrin). 1, 3 D + chloropicrin also shows efficacy against the fungal pests in this region. However, this MB alternative has significant regulatory and technical limitations that are likely to result in negative economic impacts (please see the summary of technical feasibility for Michigan for a discussion of these limitations). In addition to the limitations faced by Michigan growers, farmers in Georgia who farm on Karst geology are prohibited from even considering this option due to regulatory restrictions intended to mitigate groundwater contamination. When 1,3 D cannot be used, growers in this region will have no technically feasible control option where fungi are the major pests.

For nutsedge pests, which are widespread in this region, cucurbit growers do not currently have technically feasible alternatives to MB use at planting. Metam-sodium and 1,3 D + chloropicrin have shown some efficacy in small-plot trials in other vegetable crops (e.g, tomato). However, at best, metam sodium may allow at least 44 % yield loss, while 1,3 D may allow at least 29 % loss. Both often show less control than MB (in terms of population suppression) of nutsedges. These factors suggest that even this alternative will not be economically feasible even in the best-case technical scenario. It should be noted that there is evidence that both 1,3 D and methyl isothiocynate levels decline more rapidly, thus further compromising efficacy, in areas where these are repeatedly applied (Smelt et al., 1989; Ou et al., 1995; Gamliel et al., 2003). This is due to enhanced degradation of these chemicals by soil microbes (Dungan and Yates, 2003).
Other chemical alternatives to MB that have shown promise against nutsedges (e.g., pebulate) are currently unregistered for cucurbits, and are often not being developed for registration by any commercial entity.

In a new study, Culpepper and Langston (2004) conducted studies at 2 sites in spring 2003 and one site in Fall, 2004. Plot sizes were 20 feet X 32 inches (4.94 m^2). Treatments were: Methyl bromide standard (67:33 formulation), untreated control, 2 formulations of Telone (1,3 D + chloropicrin) at various doses, followed by an additional application of either chloropicrin or metam-sodium, a third formulation of 1,3 D + chloropicrin (“Inline”), and methyl iodide. An additional set of plots received the same fumigant treatments but also received an herbicide treatment (clomazone + halosulfuron) later in the season.

Watermelon – the only cucurbit crop addressed in these experiments – showed no significant (final) yield differences across any fumigant treatment. The same lack of difference was observed when herbicides were added. In fact, there was no difference in yield even when pesticide treatments were compared to the untreated control. However, nutsedge populations in the study appeared to be relatively low (e.g., 667 plants per plot or 135/m^2, in the untreated control, at the end of the study).

Furthermore, a number of important caveats must be mentioned when considering these results:

(1) Plots used were quite small, and it is not at all clear if the promising results will hold reliably in larger commercial fields. This is particularly worrisome given the highly variable results reported by other researchers for the same MB alternatives.
(2) The nutsedge populations in this study were dominated by yellow nutsedge (90 % of the total number). It is not clear if populations where purple nutsedge is dominant will be controlled as effectively. A number of other studies have indicated that purple nutsedge is a hardier species, and even in Culpepper and Langston's study, it appeared more resistant to the MB alternatives. For example, methyl iodide gave "77 % control" of yellow nutsedge, but only "37 % control" of purple nutsedge. Control in this case was apparently defined as the reduction in nutsedge populations as compared to populations in the untreated control.
(3) This study was done only with watermelons, and it is not clear if other cucurbits will respond so favorably in terms of yield, or lack of phytotoxic response. Also, a custom-built applicator had to be used for the metam-sodium applications to eliminate worker exposure risks, according to the authors. It is not yet clear if such an applicator can be mass-produced and/or used reliably in a commercial setting.

The other key pest cited for cucurbits in this region, *Pythium* rot, was not examined in this study. Thus these results do not shed additional light on whether alternative soil fumigants could be used against that pest.

Large-scale, on-farm demonstrations of optimal application methodology in a commercial setting are lacking for cucurbit crops, adding to the current lack of viability of MB alternatives in this crop system. While a combination of alternatives may replace MB in future cucurbit production in this region, it remains some years away from technical feasibility.

PART D: EMISSION CONTROL

19. TECHNIQUES THAT HAVE AND WILL BE USED TO MINIMIZE METHYL BROMIDE USE AND EMISSIONS IN THE PARTICULAR USE

TABLE 19.1: TECHNIQUES TO MINIMIZE METHYL BROMIDE USE AND EMISSIONS

TECHNIQUE OR STEP TAKEN	VIF OR HIGH BARRIER FILMS	METHYL BROMIDE DOSAGE REDUCTION	INCREASED % CHLOROPICRIN IN METHYL BROMIDE FORMULATION	LESS FREQUENT APPLICATION
WHAT USE/EMISSION REDUCTION METHODS ARE PRESENTLY ADOPTED?	Currently some growers use HDPE tarps.	Growers have switched from a 98% MB formulation to a 67 % formulation. Between 1997 and 2001, the U.S. has achieved a 36 % reduction in use rates.	From 2 % to 33 %	No
WHAT FURTHER USE/EMISSION REDUCTION STEPS WILL BE TAKEN FOR THE METHYL BROMIDE USED FOR CRITICAL USES?	Research is underway to develop use in commercial production systems	Research is underway to develop use of a 50 % MB formulation in Michigan commercial production systems. Not known if other regions are planning similar work.	Research is underway to develop use of a 50 % MB formulation in Michigan commercial production systems. Not known if other regions are planning similar work.	The U.S. anticipates that the decreasing supply of methyl bromide will motivate growers to try less frequent applications.
OTHER MEASURES *(please describe)*	Examination of promising but presently unregistered alternative fumigants and herbicides, alone or in combination with non-chemical methods, is planned in all regions (Please see Section 17 for each region for details)	Measures adopted in Michigan will likely be used in the other regions when fungi are the only key pests involved	Measures adopted in Michigan will likely be used in the other regions when fungi are the only key pests involved	Unknown

20. IF METHYL BROMIDE EMISSION REDUCTION TECHNIQUES ARE NOT BEING USED, OR ARE NOT PLANNED FOR THE CIRCUMSTANCES OF THE NOMINATION, STATE REASONS:

Reduced methyl bromide concentrations in mixtures, cultural practices, and the extensive use of tarpaulins to cover land treated with MB has resulted in reduced emissions.

PART E: ECONOMIC ASSESSMENT

Economic data from the 2004 submission for all applicants were not substantially different from those in 2003 (greater or less than a 10% change in costs and revenue). Given these insignificant differences, the economic analyses were not updated for any applicants other than Michigan, which was updated to reflect a change in the requested pounds of MB.

The following economic assessment is organized by MB critical use application. Individual crops within each application are examined first and are followed by aggregate measures for each application. Cost of MB and alternatives are given in table 21.1. Table 22.1 lists net and gross revenues. Expected losses when using MB r alternatives are further decomposed in tables E1 through E13.

Please note that in this study net revenue is calculated as gross revenue minus operating costs. This is a good measure as to the direct losses of income that may be suffered by the users. It should be noted that net revenue does not represent net income to the users. Net income, which indicates profitability of an operation of an enterprise, is gross revenue minus the sum of operating and fixed costs. Net income should be smaller than the net revenue measured in this study. We did not include fixed costs because it is often difficult to measure and verify.

21. OPERATING COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD:

TABLE 21.1: MICHIGAN CUCURBITS - OPERATING COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD

ALTERNATIVE	YIELD*	COST IN YEAR 1 *(US$/ha)*	COST IN YEAR 2 *(US$/ha)*	COST IN YEAR 3 *(US$/ha)*
Cucumber				
Methyl Bromide	100%	$17,848	$17,848	$17,848
1,3-D + Chloropicrin	94%	$17,182	$17,182	$17,182
Melon				
Methyl Bromide	100%	$8,220	$8,220	$8,220
1,3-D + Chloropicrin	94%	$8,132	$8,132	$8,132
Winter Squash				
Methyl Bromide	100%	$11,855	$11,855	$11,855
1,3-D + Chloropicrin	94%	$12,071	$12,071	$12,071
Zucchini				
Methyl Bromide	100%	$16,522	$16,522	$16,522
1,3-D + Chloropicrin	94%	$15,464	$15,464	$15,464

** As percentage of typical or 3-year average yield, compared to methyl bromide.*

TABLE 21.2 : SOUTHEASTERN U.S. (EXCEPT GEORGIA) CUCURBITS - COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD

ALTERNATIVE	YIELD*	COST IN YEAR 1 *(US$/ha)*	COST IN YEAR 2 *(US$/ha)*	COST IN YEAR 3 *(US$/ha)*
Cucumber				
Methyl Bromide	100%	$10,121	$10,121	$10,121
1,3-D + Chloropicrin	71%	$9,809	$9,809	$9,809
Metam-sodium	54%	$9,338	$9,338	$9,338
Melons				
Methyl Bromide	100%	$9,168	$9,168	$9,168
1,3-D + Chloropicrin	71%	$9,076	$9,076	$9,076
Metam-sodium	54%	$8,795	$8,795	$8,795
Squash				
Methyl Bromide	100%	$5,851	$5,851	$5,851
1,3-D + Chloropicrin	71%	$6,171	$6,171	$6,171
Metam-sodium	54%	$6,025	$6,025	$6,025

** As percentage of typical or 3-year average yield, compared to methyl bromide.*

TABLE 21.3 : GEORGIA CUCURBITS - COSTS OF ALTERNATIVES COMPARED TO METHYL BROMIDE OVER 3-YEAR PERIOD

ALTERNATIVE	YIELD*	COST IN YEAR 1 *(US$/ha)*	COST IN YEAR 2 *(US$/ha)*	COST IN YEAR 3 *(US$/ha)*
Cucumber				
Methyl Bromide	100%	$27,926	$27,926	$27,926
1,3-D + Chloropicrin	71%	$24,592	$24,592	$24,592
Metam-sodium	54%	$22,307	$22,307	$22,307
Melon				
Methyl Bromide	100%	$18,714	$18,714	$18,714
1,3-D + Chloropicrin	71%	$16,260	$16,260	$16,260
Metam-sodium	54%	$14,965	$14,965	$14,965
Squash				
Methyl Bromide	100%	$21,081	$21,081	$21,081
1,3-D + Chloropicrin	71%	$17,708	$17,708	$17,708
Metam-sodium	54%	$16,007	$16,007	$16,007

** As percentage of typical or 3-year average yield, compared to methyl bromide.*

22. GROSS AND NET REVENUE:

TABLE 22.1: MICHIGAN CUCURBITS – YEAR 1, 2, AND 3 GROSS AND NET REVENUES

YEAR 1, 2, AND 3		
ALTERNATIVES *(as shown in question 21)*	GROSS REVENUE FOR LAST REPORTED YEAR *(US$/ha)*	NET REVENUE FOR LAST REPORTED YEAR *(US$/ha)*
Cucumber		
Methyl Bromide	$25,656	$7,807
1,3-D + Chloropicrin	$22,911	$5,728
Melon		
Methyl Bromide	$14,069	$5,848
1,3-D + Chloropicrin	$12,563	$4,431
Winter Squash		
Methyl Bromide	$13,282	$1,427
1,3-D + Chloropicrin	$11,860	$(210)
Zucchini		
Methyl Bromide	$13,484	$(3,038)
1,3-D + Chloropicrin	$12,041	$(3,423)
All Michigan Cucurbits		
Methyl Bromide	$19,149	$17,100
1,3-D + Chloropicrin	$17,100	$1,825

NOTE: Year 1 equals year 2 and 3.

TABLE 22.2: SOUTHEASTERN U.S. (EXCEPT GEORGIA) CUCURBITS – YEAR 1, 2, AND 3 GROSS AND NET REVENUES

YEAR 1, 2, AND 3		
ALTERNATIVES *(as shown in question 21)*	**GROSS REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*	**NET REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*
Cucumber		
Methyl Bromide	$11,589	$1,468
1,3-D + Chloropicrin	$8,228	$1,581
Metam-sodium	$(6,490)	$(2,848)
Melon		
Methyl Bromide	$12,775	$3,608
1,3-D + Chloropicrin	$9,070	$(5)
Metam-sodium	$7,154	$(1,640)
Squash		
Methyl Bromide	$7,628	$1,777
1,3-D + Chloropicrin	$5,416	$(755)
Metam-sodium	$4,272	$(1,754)
All Southeastern USA Cucurbits		
Methyl Bromide	$12,315	$4,131
1,3-D + Chloropicrin	$8,744	$1,249
Metam-sodium	$6,896	$23

NOTE: Year 1 equals year 2 and 3.

TABLE 22.3: GEORGIA CUCURBITS – YEAR 1, 2, AND 3 GROSS AND NET REVENUES

YEAR 1, 2, AND 3		
ALTERNATIVES *(as shown in question 21)*	**GROSS REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*	**NET REVENUE FOR LAST REPORTED YEAR** *(US$/ha)*
Cucumber		
Methyl Bromide	$34,491	$6,565
1,3-D + Chloropicrin	$24,488	$(103)
Metam-sodium	$19,315	$(2,992)
Melon		
Methyl Bromide	$27,915	$9,201
1,3-D + Chloropicrin	$19,820	$3,560
Metam-sodium	$15,633	$668
Squash		
Methyl Bromide	$32,603	$11,522
1,3-D + Chloropicrin	$23,148	$5,440
Metam-sodium	$18,258	$2,251
All Georgia Cucurbits		
Methyl Bromide	$34,621	$13,840
1,3-D + Chloropicrin	$24,581	$6,610
Metam-sodium	$19,388	$2,969

NOTE: Year 1 equals year 2 and 3.

MEASURES OF ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN CUCUMBER - TABLE E.1: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN CUCUMBER	METHYL BROMIDE	1,3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	2,018	1,897
* PRICE PER UNIT (US$)	$12	$12
= GROSS REVENUE PER HECTARE (US$)	$25,655	$22,910
- OPERATING COSTS PER HECTARE (US$)	$17,848	$17,182
= NET REVENUE PER HECTARE (US$)	$7,807	$5,728
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$2,079
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$17
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	8%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	27%
5. OPERATING PROFIT MARGIN (%)	30%	25%

MICHIGAN MELON - TABLE E.2: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN MELON	METHYL BROMIDE	1,3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	145	136
* PRICE PER UNIT (US$)	$97	$92
= GROSS REVENUE PER HECTARE (US$)	$14,069	$12,563
- OPERATING COSTS PER HECTARE (US$)	$8,220	$8,132
= NET REVENUE PER HECTARE (US$)	$5,848	$4,431
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$1,417
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$12
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	10%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	24%
5. OPERATING PROFIT MARGIN (%)	42%	35%

MICHIGAN WINTER SQUASH- TABLE E.3: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN WINTER SQUASH	METHYL BROMIDE	1,3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	1,063	999
* PRICE PER UNIT (US$)	$13	$12
= GROSS REVENUE PER HECTARE (US$)	$13,282	$11,861
- OPERATING COSTS PER HECTARE (US$)	$11,855	$12,071
= NET REVENUE PER HECTARE (US$)	$1,427	$(210)
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$1,637
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$14
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	12%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	115%
5. OPERATING PROFIT MARGIN (%)	11%	-2%

MICHIGAN ZUCCHINI - TABLE E.4: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

MICHIGAN ZUCCHINI	METHYL BROMIDE	1,3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	2,368	2,226
* PRICE PER UNIT (US$)	$6	$5
= GROSS REVENUE PER HECTARE (US$)	$13,484	$12,041
- OPERATING COSTS PER HECTARE (US$)	$16,522	$15,464
= NET REVENUE PER HECTARE (US$)	$(3,038)	$(3,423)
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$385
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$3
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	3%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	-13%
5. OPERATING PROFIT MARGIN (%)	-23%	-28%

ALL MICHIGAN CUCURBITS - TABLE E.5: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

ALL MICHIGAN CUCURBITS	METHYL BROMIDE	1,3-D + CHLOROPICRIN
YIELD LOSS (%)	0%	6%
YIELD PER HECTARE	1,708	1,606
* PRICE PER UNIT (US$)	$11	$11
= GROSS REVENUE PER HECTARE (US$)	$19,149	$17,100
- OPERATING COSTS PER HECTARE (US$)	$15,091	$15,275
= NET REVENUE PER HECTARE (US$)	$4,058	$1,825
FIVE LOSS MEASURES *		
1. LOSS PER HECTARE (US$)	$0	$2,232
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$18
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	12%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	55%
5. OPERATING PROFIT MARGIN (%)	21%	11%

SOUTHEASTERN U.S. (EXCEPT GEORGIA) CUCUMBER - TABLE E.6: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

SOUTHEAST U.S. (EXCEPT GEORGIA) CUCUMBER	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	828	588	464
* PRICE PER UNIT (US$)	$14	$14	$14
= GROSS REVENUE PER HECTARE (US$)	$11,589	$8,228	$6,490
- OPERATING COSTS PER HECTARE (US$)	$10,121	$9,809	$9,338
= NET REVENUE PER HECTARE (US$)	$1,468	$(1,581)	$(2,848)
FIVE LOSS MEASURES			
1. LOSS PER HECTARE (US$)	$0	$3,049	$4,316
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$20	$29
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	26%	37%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	208%	294%
5. OPERATING PROFIT MARGIN (%)	13%	-19%	-44%

SOUTHEASTERN U.S. (EXCEPT GEORGIA) MELON - TABLE E.7: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

SOUTHEAST U.S. (EXCEPT GEORGIA) MELON	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	815	579	457
* PRICE PER UNIT (US$)	$16	$16	$16
= GROSS REVENUE PER HECTARE (US$)	$12,775	$9,070	$7,154
- OPERATING COSTS PER HECTARE (US$)	$9,168	$9,076	$8,795
= NET REVENUE PER HECTARE (US$)	$3,608	$(5)	$(1,640)
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$3,613	$5,248
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$24	$35
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	28%	41%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	100%	145%
5. OPERATING PROFIT MARGIN (%)	28%	0%	-23%

SOUTHEASTERN U.S. (EXCEPT GEORGIA) SQUASH - TABLE E.8: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

SOUTHEAST U.S. (EXCEPT GEORGIA) SQUASH	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	311	221	174
* PRICE PER UNIT (US$)	$25	$25	$25
= GROSS REVENUE PER HECTARE (US$)	$7,628	$5,416	$4,272
- OPERATING COSTS PER HECTARE (US$)	$5,851	$6,171	$6,025
= NET REVENUE PER HECTARE (US$)	$1,777	$(755)	$(1,754)
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$2,532	$3,531
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$17	$24
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	33%	46%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	142%	199%
5. OPERATING PROFIT MARGIN (%)	23%	-14%	-41%

ALL SOUTHEASTERN U.S. (EXCEPT GEORGIA) CUCURBITS - TABLE E.9: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

ALL SOUTHEAST U.S. (EXCEPT GEORGIA) CUCURBITS	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	749	532	420
* PRICE PER UNIT (US$)	$16	$16	$16
= GROSS REVENUE PER HECTARE (US$)	$12,315	$8,744	$6,896
- OPERATING COSTS PER HECTARE (US$)	$8,184	$7,495	$6,874
= NET REVENUE PER HECTARE (US$)	$4,131	$1,249	$23
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$2,883	$4,108
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$19	$27
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	23%	33%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	70%	99%
5. OPERATING PROFIT MARGIN (%)	34%	14%	0%

GEORGIA CUCUMBER - TABLE E.10: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

GEORGIA CUCUMBER	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	4,122	2,926	2,308
* PRICE PER UNIT (US$)	$8	$8	$8
= GROSS REVENUE PER HECTARE (US$)	$34,491	$24,488	$19,315
- OPERATING COSTS PER HECTARE (US$)	$27,926	$24,592	$22,307
= NET REVENUE PER HECTARE (US$)	$6,565	$(103)	$(2,992)
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$6,668	$9,557
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$44	$64
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	19%	28%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	102%	146%
5. OPERATING PROFIT MARGIN (%)	19%	0%	-15%

GEORGIA MELON - TABLE E.11: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

GEORGIA MELON	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	2,975	2,112	1,666
* PRICE PER UNIT (US$)	$9	$9	$9
= GROSS REVENUE PER HECTARE (US$)	$27,915	$19,820	$15,633
- OPERATING COSTS PER HECTARE (US$)	$18,714	$16,260	$14,965
= NET REVENUE PER HECTARE (US$)	$9,201	$3,560	$668
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$5,641	$8,533
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$38	$57
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	20%	31%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	61%	93%
5. OPERATING PROFIT MARGIN (%)	33%	18%	4%

GEORGIA SQUASH - TABLE E.12: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

GEORGIA SQUASH	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	4,448	3,158	2,491
* PRICE PER UNIT (US$)	$7	$7	$7
= GROSS REVENUE PER HECTARE (US$)	$32,603	$23,148	$18,258
- OPERATING COSTS PER HECTARE (US$)	$21,081	$17,708	$16,007
= NET REVENUE PER HECTARE (US$)	$11,522	$5,440	$2,251
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$6,082	$9,271
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$41	$62
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	19%	28%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	53%	80%
5. OPERATING PROFIT MARGIN (%)	35%	24%	12%

ALL GEORGIA CUCURBITS - TABLE E.13: ECONOMIC IMPACTS OF METHYL BROMIDE ALTERNATIVES

ALL GEORGIA CUCURBITS	METHYL BROMIDE	1,3-D + CHLOROPICRIN	METAM-SODIUM
YIELD LOSS (%)	0%	29%	44%
YIELD PER HECTARE	3,502	2,486	1,961
* PRICE PER UNIT (US$)	$10	$10	$10
= GROSS REVENUE PER HECTARE (US$)	$34,621	$24,581	$19,388
- OPERATING COSTS PER HECTARE (US$)	$20,781	$17,971	$16,419
= NET REVENUE PER HECTARE (US$)	$13,840	$6,610	$2,968
FIVE LOSS MEASURES *			
1. LOSS PER HECTARE (US$)	$0	$7,230	$10,871
2. LOSS PER KILOGRAM OF METHYL BROMIDE (US$)	$0	$48	$72
3. LOSS AS A PERCENTAGE OF GROSS REVENUE (%)	0%	21%	31%
4. LOSS AS A PERCENTAGE OF NET REVENUE (%)	0%	52%	79%
5. OPERATING PROFIT MARGIN (%)	40%	27%	15%

SUMMARY OF ECONOMIC FEASIBILITY

There are currently few alternatives to methyl bromide for use in cucurbits. Furthermore, there are several factors that limit possible alternatives' usability and efficacy from place to place. These include pest complex, climate, and regulatory restrictions. The two most promising alternatives to methyl bromide in Georgia and the Southeastern USA for control of nut-sedge in cucurbits (1,3-D + chloropicrin and metam-sodium) are considered not technically feasible. This derives from regulatory restrictions and the magnitude of resulting expected yield losses. Economic data representing Georgia and Southeastern USA cucurbit growing conditions are thus included in the economic assessment as a supplement to the biological review to illustrate the impacts of using MeBr alternatives, not to gauge them with respect to economic feasibility. In Michigan 1,3-D + chloropicrin is considered technically feasible.

Michigan

The US concludes that, at present, no economically feasible alternatives to MeBr exist for use in Michigan cucurbit production. The US has arrived at this conclusion by examining the individual crops within the Michigan cucurbit sector and then examining the sector as a whole. Yield loss and missed market windows, which are discussed individually below, have proven most important in reaching this conclusion.

1. Yield Loss

Expected yield losses of 6% are anticipated throughout Michigan cucurbit production.

2. Missed Market Windows

The US agrees with Michigan's assertion that growers will likely receive significantly lower prices for their produce if they switch to 1,3-D + chloropicrin. This is due to changes in the harvest schedule caused by the above described soil temperature complications and extended plant back intervals when using 1,3-D + chloropicrin.

The analysis of this effect is based on the fact that prices farmers receive for their cucurbits vary widely over the course of the growing season. Driving these fluctuations are the forces of supply and demand. Early in the growing season, when relatively few cucurbits are harvested, the supply is at its lowest and the market price is at its highest. As harvested quantities increase, the price declines. In order to maximize their revenues, cucurbit growers manage their production systems with the goal of harvesting the largest possible quantity of cucurbits when the prices are at their highs. The ability to sell produce at these higher prices makes a significant contribution toward the profitability of cucurbit operations.

To describe economic conditions in Michigan, EPA used weekly and monthly cucurbit sales and production data from the U.S. Department of Agriculture for the previous three years to gauge the impact of early season price fluctuations on gross revenues. Though data availability was limiting, analysts assumed that if cucurbit growers adjust the timing of their production system, as required when using 1,3-D + Chloropicrin, gross revenues will decline by approximately 5% over the course of the growing season, due solely to price effects. The season average price was reduced by 5% in the analysis of the alternatives to reflect this effect. Based on currently available information, the U.S. believes this reduction in price serves as a reasonable indicator of the typical effect of planting delays resulting when MB alternatives are used in Michigan.

Southeastern U.S. (Except Georgia)

No technically (and thus economically) feasible alternatives to MB are presently available to the effected cucurbit growers. As such, the US concludes that use of MB is critical in Southeastern U.S. cucurbit production.

The applicant provided no data on the operating costs of alternatives. Analysts assumed, however, that these costs were similar to those of methyl bromide with slight upward adjustments for the costs of applying the alternatives and a slight downward adjustment for the cost of the alternative product. In addition, the applicant did not provide data for second crops (including revenues and operating costs). Analysts assumed that Southeastern cucurbits are grown in a single crop production system. However, if double cropping is practiced in the actual production system, this assumption could make the critical need for MB appear smaller than it actually is, because the value the second crop derives from methyl bromide is not included in the analysis

Other potentially significant economic factors, such as price reductions due to missed market windows, were not analyzed for this region, as the case for critical use of MB is sufficiently strong based solely on yield loss.

Georgia

No technically (and thus economically) feasible alternatives to MB are presently available to the effected cucurbit growers. As such, the US conclude that use of MB is critical in Georgia cucurbit production.

Other potentially significant economic factors, such as price reductions due to missed market windows, were not analyzed for this region, as the case for critical use of MB is sufficiently strong based solely on yield loss.

Economic analysis of Georgia growing conditions included cost and production data representing a second cucurbits or peppers crop.

PART F. FUTURE PLANS

23. WHAT ACTIONS WILL BE TAKEN TO RAPIDLY DEVELOP AND DEPLOY ALTERNATIVES FOR THIS CROP?

Consortia will develop timelines describing the transition from MB. In addition, ongoing research is examining alternative technologies to develop protocols for maximizing the efficacy of alternatives.

24. HOW DO YOU PLAN TO MINIMIZE THE USE OF METHYL BROMIDE FOR THE CRITICAL USE IN THE FUTURE?

Consortia will develop timelines describing the transition from MB. In addition, ongoing research is examining alternative technologies to develop protocols for maximizing the efficacy of alternatives.

25. ADDITIONAL COMMENTS ON THE NOMINATION?

The MB critical use exemption nomination for cucurbits has been reviewed by the U. S. Environmental Protection Agency and the U. S. Department of Agriculture and meets the guidelines of The *Montreal Protocol on Substances That Deplete the Ozone Layer*. This nomination includes requests for MB only for those fields where sufficient pest control can not be achieved otherwise. The loss of MB would result in a significant market disruption. The effort to avoid market disruption provides the basis for nomination of this sector for critical use exemption of MB.

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APPENDIX A. 2007 Methyl Bromide Usage Numerical Index (BUNI).

Methyl Bromide Critical Use Exemption Process
2007 Methyl Bromide Usage Numerical Index (BUNI)

Date:	**1/28/2005**	**Average Hectares in the US:**	**175,270**
Sector:	**CUCURBITS**	**% of Average Hectares Requested:**	**5%**

REGION	2007 Amount of Request Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)	2001 & 2002 Average Use* Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)	Quarantine and Pre-Shipment	Regional Hectares** 2003 Area (ha)	% of Request	Research Amount (kgs)
MICHIGAN	**26,592**	**221**	**120**	27,867	232	120	**0%**	**8,620**	**3%**	**941**
SOUTHEASTERN US	**959,129**	**6,386**	**150**	772,531	5,144	150	**0%**	**18,858**	**34%**	
GEORGIA	**405,837**	**2,702**	**150**	423,555	2,820	150	**0%**	**25,204**	**11%**	
TOTAL OR AVERAGE	**1,391,558**	**9,310**	**149**	**1,223,952**	**8,195**	**149**	**0%**	**52,682**	**18%**	

2007 Nomination Options REGION	Subtractions from Requested Amounts (kgs) 2007 Request	(-) Double Counting	(-) Growth	(-) Use Rate Adjustment	(-) QPS	Combined Impacts Adjustment (kgs) HIGH	LOW	MOST LIKELY IMPACT VALUE Kilograms (kgs)	Hectares (ha)	Use Rate (kg/ha)
MICHIGAN	**26,592**	-	-	-	-	26,592	26,592	**26,592**	**221**	**120**
SOUTHEASTERN US	**959,129**	-	186,599	-	-	509,870	324,463	**368,034**	**2,450**	**150**
GEORGIA	**405,837**	-	7,142	-	-	271,266	182,501	**203,361**	**1,354**	**150**
Nomination Amount	**1,391,558**	**1,391,558**	**1,197,818**	**1,197,818**	**1,197,818**	**807,728**	**533,556**	**597,986**	**4,026**	**149**
% Reduction from Initial Request	**0%**	**0%**	**14%**	**14%**	**14%**	**42%**	**62%**	**57%**	**57%**	**1%**

Adjustments to Requested Amounts	Use Rate (kg/ha)		(%) Karst (Telone)		(%) 100 ft Buffer Zones		(%) Key Pest Distribution		Regulatory Issues (%)		Unsuitable Terrain (%)		Cold Soil Temp (%)		Combined Impacts (%)	
REGION	Low	EPA	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	**HIGH**	**LOW**
MICHIGAN *	120	120	0%	0%	0%	0%	100%	100%	0%	0%	0%	0%	100%	100%	**100%**	**100%**
SOUTHEASTERN US	150	150	0%	0%	0%	0%	66%	42%	0%	0%	0%	0%	0%	0%	**66%**	**42%**
GEORGIA **	150	150	8%	8%	0%	0%	64%	42%	0%	0%	0%	0%	0%	0%	**68%**	**46%**

Other Considerations REGION	Dichotomous Variables (Y/N) Strip Bed Treatment	Currently Use Alternatives?	Research / Transition Plans	Tarps / Deep Injection Used	Pest-free Cert. Requirement	Other Issues Change from Prior CUE Request (+/-)	Verified Historic MeBr Use / State	Frequency of Treatment	Economic Analysis Loss per Hectare (US$/ha)	Loss per Kg of MeBr (US$/kg)	Loss as a % of Gross Revenue	Loss as a % of Net Revenue	Quality/ Time/ Market Window/ Yield Loss (%)	Marginal Strategy
MICHIGAN	Yes	Yes	Yes	Tarp	No	-	Yes	1/year	$ 2,232	$ 46	12%	55%	47% Yield + Timing Loss	Metam-Sodium
SOUTHEASTERN US	Yes	Yes	Yes	Tarp	No	+	Yes	1/year	$ 2,883	$ 19	23%	70%	29% Yield Loss	1,3-D + Pic
	Yes	Yes	Yes	Tarp	No	+	Yes	1/year	$ 4,108	$ 27	33%	99%	44% Yield Loss	Metam-Sodium + Pic
GEORGIA	Yes	Yes	Yes	Tarp	No	0	Yes	1/year	$ 7,230	$ 48	21%	52%	29% Yield Loss	1,3-D + Pic
	Yes	Yes	Yes	Tarp	No	0	Yes	1/year	$10,871	$ 72	31%	79%	44% Yield Loss	Metam-Sodium + Pic

Conversion Units: 1 Pound = 0.453592 Kilograms 1 Acre = 0.404686 Hectare

* Michigan rates are higher for 2007 based on more current information.

** Georgia rotates crops with solanaceous crops therefore we had to balance the distribution with the other sectors in Georgia's application.

Most Likely Impact Value: High 24% Low 77%

Footnotes for Appendix A:

Values may not sum exactly due to rounding.

1. **Average Hectares in the US** – Average Hectares in the US is the average of 2001 and 2002 total hectares in the US in this crop when available. These figures were obtained from the USDA National Agricultural Statistics Service.
2. **% of Average Hectares Requested** - Percent (%) of Average Hectares Requested is the total area in the sector's request divided by the Average Hectares in the US. Note, however, that the NASS categories do not always correspond one to one with the sector nominations in the U.S. CUE nomination (e.g., roma and cherry tomatoes were included in the applicant's request, but were not included in NASS surveys). Values greater than 100 percent are due to the inclusion of these varieties in the U.S. CUE request that were not included in the USDA NASS: nevertheless, these numbers are often instructive in assessing the requested coverage of applications received from growers.
3. **2007 Amount of Request** – The 2007 amount of request is the actual amount requested by applicants given in total pounds active ingredient of methyl bromide, total acres of methyl bromide use, and application rate in pounds active ingredient of methyl bromide per acre. U.S. units of measure were used to describe the initial request and then were converted to metric units to calculate the amount of the US nomination.
4. **2001 & 2002 Average Use** – The 2001 & 2002 Average Use is the average of the 2001 and 2002 historical usage figures provided by the applicants given in total pounds active ingredient of methyl bromide, total acres of methyl bromide use, and application rate in pounds active ingredient of methyl bromide per acre. Adjustments are made when necessary due in part to unavailable 2002 estimates in which case only the 2001 average use figure is used.
5. **Quarantine and Pre-Shipment** – Quarantine and pre-shipment (QPS) hectares is the percentage (%) of the applicant's request subject to QPS treatments.
6. **Regional Hectares, 2001 & 2002 Average Hectares** – Regional Hectares, 2001 & 2002 Average Hectares is the 2001 and 2002 average estimate of hectares within the defined region. These figures are taken from various sources to ensure an accurate estimate. The sources are from the USDA National Agricultural Statistics Service and from other governmental sources such as the Georgia Acreage estimates.
7. **Regional Hectares, Requested Acreage %** - Regional Hectares, Requested Acreage % is the area in the applicant's request divided by the total area planted in that crop in the region covered by the request as found in the USDA National Agricultural Statistics Service (NASS). Note, however, that the NASS categories do not always correspond one to one with the sector nominations in the U.S. CUE nomination (e.g., roma and cherry tomatoes were included in the applicant's request, but were not included in NASS surveys). Values greater than 100 percent are due to the inclusion of these varieties in the U.S. CUE request that were not included in the USDA NASS: nevertheless, these numbers are often instructive in assessing the requested coverage of applications received from growers.
8. **2007 Nomination Options** – 2007 Nomination Options are the options of the inclusion of various factors used to adjust the initial applicant request into the nomination figure.
9. **Subtractions from Requested Amounts** – Subtractions from Requested Amounts are the elements that were subtracted from the initial request amount.
10. **Subtractions from Requested Amounts, 2007 Request** – Subtractions from Requested Amounts, 2007 Request is the starting point for all calculations. This is the amount of the applicant request in kilograms.
11. **Subtractions from Requested Amounts, Double Counting** - Subtractions from Requested Amounts, Double Counting is the estimate measured in kilograms in situations where an applicant has made a request for a CUE with an individual application while their consortium has also made a request for a CUE on their behalf in the consortium application. In these cases the double counting is removed from the consortium application and the individual application takes precedence.
12. **Subtractions from Requested Amounts, Growth or 2002 CUE Comparison** - Subtractions from Requested Amounts, Growth or 2002 CUE Comparison is the greatest reduction of the estimate measured in kilograms of either the difference in the amount of methyl bromide requested by the applicant that is greater than that historically used or treated at a higher use rate or the difference in the 2007 request from an applicant's 2002 CUE application compared with the 2007 request from the applicant's 2003 CUE application.
13. **Subtractions from Requested Amounts, QPS** - Subtractions from Requested Amounts, QPS is the estimate measured in kilograms of the request subject to QPS treatments. This subtraction estimate is calculated as the 2007 Request minus Double Counting, minus Growth or 2002 CUE Comparison then

multiplied by the percentage subject to QPS treatments. *Subtraction from Requested Amounts, QPS = (2007 Request – Double Counting – Growth)*(QPS %)*

14. **Subtraction from Requested Amounts, Use Rate Difference** – Subtractions from requested amounts, use rate difference is the estimate measured in kilograms of the lower of the historic use rate or the requested use rate. The subtraction estimate is calculated as the 2007 Request minus Double Counting, minus Growth or 2002 CUE Comparison, minus the QPS amount, if applicable, minus the difference between the requested use rate and the lowest use rate applied to the remaining hectares.
15. **Adjustments to Requested Amounts** – Adjustments to requested amounts were factors that reduced to total amount of methyl bromide requested by factoring in the specific situations were the applicant could use alternatives to methyl bromide. These are calculated as proportions of the total request. We have tried to make the adjustment to the requested amounts in the most appropriate category when the adjustment could fall into more than one category.
16. **(%) Karst topography** – Percent karst topography is the proportion of the land area in a nomination that is characterized by karst formations. In these areas, the groundwater can easily become contaminated by pesticides or their residues. Regulations are often in place to control the use of pesticide of concern. Dade County, Florida, has a ban on the use of 1,3D due to its karst topography.
17. **(%) 100 ft Buffer Zones** – Percentage of the acreage of a field where certain alternatives to methyl bromide cannot be used due the requirement that a 100 foot buffer be maintained between the application site and any inhabited structure.
18. **(%) Key Pest Impacts** - Percent (%) of the requested area with moderate to severe pest problems. Key pests are those that are not adequately controlled by MB alternatives. For example, the key pest in Michigan peppers, *Phytophthora* spp. infests approximately 30% of the vegetable growing area. In southern states the key pest in peppers is nutsedge.
19. **Regulatory Issues (%)** - Regulatory issues (%) is the percent (%) of the requested area where alternatives cannot be legally used (e.g., township caps) pursuant to state and local limits on their use.
20. **Unsuitable Terrain (%)** – Unsuitable terrain (%) is the percent (%) of the requested area where alternatives cannot be used due to soil type (e.g., heavy clay soils may not show adequate performance) or terrain configuration, such as hilly terrain. Where the use of alternatives poses application and coverage problems.
21. **Cold Soil Temperatures** – Cold soil temperatures is the proportion of the requested acreage where soil temperatures remain too low to enable the use of methyl bromide alternatives and still have sufficient time to produce the normal (one or two) number of crops per season or to allow harvest sufficiently early to obtain the high prices prevailing in the local market at the beginning of the season.
22. **Combined Impacts (%)** - Total combined impacts are the percent (%) of the requested area where alternatives cannot be used due to key pest, regulatory, soil impacts, temperature, etc. In each case the total area impacted is the conjoined area that is impacted by any individual impact. The effects were assumed to be independently distributed unless contrary evidence was available (e.g., affects are known to be mutually exclusive). For example, if 50% of the requested area had moderate to severe key pest pressure and 50% of the requested area had karst topography, then 75% of the area was assumed to require methyl bromide rather than the alternative. This was calculated as follows: 50% affected by key pests and an additional 25% (50% of 50%) affected by karst topography.
23. **Qualifying Area** - Qualifying area (ha) is calculated by multiplying the adjusted hectares by the combined impacts.
24. **Use Rate** - Use rate is the lower of requested use rate for 2007 or the historic average use rate.
25. **CUE Nominated amount** - CUE nominated amount is calculated by multiplying the qualifying area by the use rate.
26. **Percent Reduction** - Percent reduction from initial request is the percentage of the initial request that did not qualify for the CUE nomination.
27. **Sum of CUE Nominations in Sector** - Self-explanatory.
28. **Total US Sector Nomination** - Total U.S. sector nomination is the most likely estimate of the amount needed in that sector.
29. **Dichotomous Variables** – dichotomous variables are those which take one of two values, for example, 0 or 1, yes or no. These variables were used to categorize the uses during the preparation of the nomination.
30. **Strip Bed Treatment** – Strip bed treatment is ‘yes’ if the applicant uses such treatment, no otherwise.
31. **Currently Use Alternatives** – Currently use alternatives is ‘yes’ if the applicant uses alternatives for some portion of pesticide use on the crop for which an application to use methyl bromide is made.

32. **Research/ Transition Plans** – Research/ Transition Plans is ‘yes’ when the applicant has indicated that there is research underway to test alternatives or if applicant has a plan to transition to alternatives.
33. **Tarps/ Deep Injection Used** – Because all pre-plant methyl bromide use in the US is either with tarps or by deep injection, this variable takes on the value ‘tarp’ when tarps are used and ‘deep’ when deep injection is used.
34. **Pest-free cert. Required** - This variable is a ‘yes’ when the product must be certified as ‘pest-free’ in order to be sold
35. **Other Issues**.- Other issues is a short reminder of other elements of an application that were checked
36. **Change from Prior CUE Request**- This variable takes a ‘+’ if the current request is larger than the previous request, a ‘0’ if the current request is equal to the previous request, and a ‘-‘ if the current request is smaller that the previous request.
37. **Verified Historic Use/ State**- This item indicates whether the amounts requested by administrative area have been compared to records of historic use in that area.
38. **Frequency of Treatment** – This indicates how often methyl bromide is applied in the sector. Frequency varies from multiple times per year to once in several decades.
39. **Economic Analysis** – provides summary economic information for the applications.
40. **Loss per Hectare** – This measures the total loss per hectare when a specific alternative is used in place of methyl bromide. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
41. **Loss per Kilogram of Methyl Bromide** – This measures the total loss per kilogram of methyl bromide when it is replaced with an alternative. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
42. **Loss as a % of Gross revenue** – This measures the loss as a proportion of gross (total) revenue. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars.
43. **Loss as a % of Net Operating Revenue** -This measures loss as a proportion of total revenue minus operating costs. Loss comprises both the monetized value of yield loss (relative to yields obtained with methyl bromide) and any additional costs incurred through use of the alternative. It is measured in current US dollars. This item is also called net cash returns.
44. **Quality/ Time/ Market Window/Yield Loss (%)** – When this measure is available it measures the sum of losses including quality losses, non-productive time, missed market windows and other yield losses when using the marginal strategy.
45. **Marginal Strategy** -This is the strategy that a particular methyl bromide user would use if not permitted to use methyl bromide.